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STUDIES ON
THE BIOLOGY OF THE COD IN GREENLAND WATERS

BY

PAUL M. HANSEN

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Chart of Greenland, showing position of the places mentioned in the text. The sign ⊙ indicates settlements after which the districts are named.

Foreword.

THIS work, a summary of what we know at present regarding the biology of the Cod in Greenland waters, is based on continuous investigations over several years undertaken by the Greenland Administration; the marking experiments in collaboration with "Kommissionen for Danmarks Fiskeri- og Havundersøgelser".

For the assistance and interest received during this work from the Greenland Administration I am greatly indebted to the late Director JENS DAUGAARD JENSEN and the former Director KNUD OLDENDOW.

Next, I beg to tender my thanks to the present Director ESKE BRUN; during the war years, when all communication between Greenland and Denmark was severed, he ordered measurement data and otoliths to be collected every year as usually, and thus the war years did not interrupt the investigations on the stock of cod and their composition in year-classes.

Valuable help and support have been accorded me in various ways by the officials of the Greenland Administration, both at home and in Greenland, as well as by other Danes and Greenlanders, especially in the collection of material[1]). To mention any special names would be impossible; I must be content with expressing my sincere thanks to all.

I am grateful to the Director of the Marine Biological Laboratory, Dr. phil. Å. VEDEL TÅNING, for his excellent cooperation, especially in the cod marking experiments; further, he has most kindly handed over to me a considerable material of cod otoliths, which on his initiative was collected by Faroese fishermen during several years from the fishing banks in Davis Strait.

Most thanks are due to Professor Dr. phil. AD. S. JENSEN, for many years the fisheries adviser of the Greenland Administration; he it was who started me on these investigations and he has always been at hand with advice and directions during the progress of the work.

And finally I have to accord my appreciation of the kindness of Dr. HARRY M. KYLE for translating this paper from the Danish.

I. Introduction.

A. Previous Investigations.

At the time when AD. S. JENSEN undertook the first practical-scientific fisheries investigations with the brig "Tjalfe" in 1908—09, the cod was a rare and but locally occurring fish at Greenland. All the same, at the investigation of AD. S. JENSEN, a cod fishery was started and a couple of Greenland fishery stations set up; this was the first beginning of a fishery which has proved of great importance to the Greenlanders; it was successful and gradually, as the cod increased in numbers due to more favourable hydrographical conditions in the Greenland waters, extended northwards along the coast of West Greenland. Until the investigations of the twenties were undertaken, nothing was known about the biological conditions of the stock of cod in Greenland waters. Thus it was not known how far the species spawned in Greenland waters and whether the young cod grew up there. Nor was it known to what extent the Greenland cod was connected with the American or the Iceland stocks. Neither the growth nor the age-composition of the stock was known and there were many problems therefore to solve and many of them could only be solved by continuous investigations over several years.

The investigations which have now been carried on for a number of years have thrown light on many of these conditions. In 1924 TÅNING with "Islands Falk" of the Danish Marine undertook the first investigations into the occurrence of the cod fry; at the same time he began marking experiments and collected a large material of cod otoliths for the determination of the age, growth and composition of the stock. It was on this occasion that for the first

[1]) For practical reasons the original figures regarding the catch of fry and the age analyses of the catches from the various years are not included in the present report, but they may be had on application to the University Library in Copenhagen.

time cod fry were proved to occur in Greenland waters. In 1925 investigations over the off-shore banks were undertaken under the direction of AD. S. JENSEN and in 1926 and 1927 the cod investigations were continued in the coastal and fjord waters from Frederikshaab to Holsteinsborg district, by means of various motor boats and from the fishery stations; these investigations were carried out by the present author. In 1928 the S.S. "Godthaab" continued the investigations over the banks and at several places along the coast. As the principal working area of the Godthaab Expedition lay chiefly in the northern part of Baffin Bay and Melville Bay, only scattered observations on the biology of the cod could be made.

The coast and fjord investigations were continued in 1929 from motor boat on the initiative of AD. S. JENSEN and were carried out each summer by the author till the summer of 1939. The war stopped the work, but a large material of cod otoliths and measurements was collected in the war years by the Greenland fishery officials at the various stations. After the war the investigations were renewed in 1946 from the new research vessel M/K "Adolf Jensen" by the Greenland Administration.

In the course of the years various papers have been published dealing with the biology of the Greenland cod. In his reports from the "Tjalfe" Expedition AD. S. JENSEN has dealt with its occurrence at Greenland in the beginning of the century (JENSEN 1909) and in "The Fishery of the Greenlanders" (1925) he refers further to the cod fishery of the Greenlanders and also to the first fisheries investigations at Greenland in 1924. The investigations of the S.S. "Dana" are discussed by JENSEN (1925 and 1926). A complete account of the results of the investigations in the twenties is given by HANSEN and JENSEN (1930 and 1931). The change in the natural conditions of the sea, which has influenced the mass occurrence of the cod in Greenland waters, is described in detail by JENSEN (1939 and 1944), who at the same time discusses various conditions affecting the biology of the cod at Greenland.

In his work on the Atlantic races of the cod SCHMIDT (1931) also deals with the cod at Greenland and here we find also the first records of marked Greenland cod recovered from Icelandic waters. The extensive marking experiments are dealt with by HANSEN, JENSEN and TÅNING (1935), who give the results of the experiments from the years 1924—1933. Further, TÅNING (1934 and 1937) has discussed various conditions affecting the migrations of the Greenland cod with special reference to the migrations to Iceland. The present author (1934) has discussed the year-class composition of the cod stock in different Greenland areas. A further survey of the same kind carries on the investigations to 1938 (HANSEN 1939). The present author has given reports (HANSEN 1931—46) concerning the investigations which were carried out yearly in Greenland waters from 1931—1939 and in 1946, with special regard for the biology of the cod. Quite brief summaries are given in 1930 (HANSEN) and in 1942 in connection with the statistical reports on Greenland. In the *Annales Biologiques* for 1943 the present author gave a review of the age-group composition of the cod stock in the years 1924—1939, the average lengths of the cod in the different age-groups and the average size of individual year-classes.

B. The Occurrence of the Cod at Greenland.

In an earlier publication (HANSEN and JENSEN 1930) the section which deals with the history of the Greenland cod fisheries describes the occurrence of the cod at Greenland in earlier years up to 1929 and in his paper on the climatic changes (1939) AD. S. JENSEN refers to the distribution of the cod at Greenland both in earlier and recent times.

It will be sufficient, therefore, to give only a brief outline here of the information recorded in these two works.

The occurrence of the cod at West Greenland has been of a periodic character. According to RINK the eighteen twenties and end of the forties have been periods of many cod. In the forties, the period we know best, a large cod fishery was carried on by foreign vessels in the Davis Strait, whilst the Danes and Greenlanders also took part in the fishery. In 1850 the cod fishery gave only a meagre result and in 1851 practically no cod were found. In both periods the cod were caught along the whole coast up to Disko Bay. For the remainder of the nineteenth century we have no notices of large occurrences of cod.

From experience we know that there have always been cod in a few of the South Greenland fjords; for example, in some fjords of the Sukkertoppen district (Kangia, Angmasivik). Cod have also been present in the Amerdlok fjord at Holsteinsborg. It was well known at Fiskenæsset in the Godthaab district, that the cod appeared as a rule every summer (August-September), and a fishery was then carried on, the dried cod being used for distribution to the poor in times of scarcity. The liver also was used in the making of oil.

In 1906 an experimental fishery for cod was undertaken by two Faroese cutters under the direction of NAPOLEON ANDREASEN, a company manager. The trials, which were carried out for the Greenland Trading Company, gave almost negative results so far as the cod was concerned. Just as little fortune came to two Faroese cutters, which made a trial fishery in 1914 from about July 19. to August 20. mainly off Sukkertop and Kangamiut. They got no cod but about 900 halibut, none of which was under 50 kg. in weight. In addition they caught large quantities of the catfish (*Anarhichas minor*) on long-lines.

When the "Tjalfe" Expedition of 1908—09 carried out its investigations, cod were only found in some quantities at Fiskenæs and in the sounds at Cape Farewell. The cod fishery, which was begun in 1911 at Fiskenæs and Sarfanguak in Amerdlok Fjord, on the initiative of AD. S. JENSEN, the leader of the Expedition, yielded only meagre results in the first six

years. In 1917 there was a marked upward tendency in the fishery, the cod appearing in that year in greater numbers and over larger areas than before. It came first into the Julianehaab district and a little later into the Frederikshaab district, since 1919 in the area of the Godthaab Fjord, after 1922 in the Sukkertoppen district and in 1927 in the Holsteinsborg district. In 1928 the cod went right up to Hunde Eiland in the Egedesminde district. In 1931 there were cod as far up as Disko Bay and in the Umanak district. In the following years the cod has appeared each year up in these northern districts. For example, in the Umanak district in 1932 over 36 tons of cod were obtained at the outposts Nugssuak and Niakornat. From the end of the thirties a few cod have been taken even at Upernavik (Jensen 1939, p. 5).

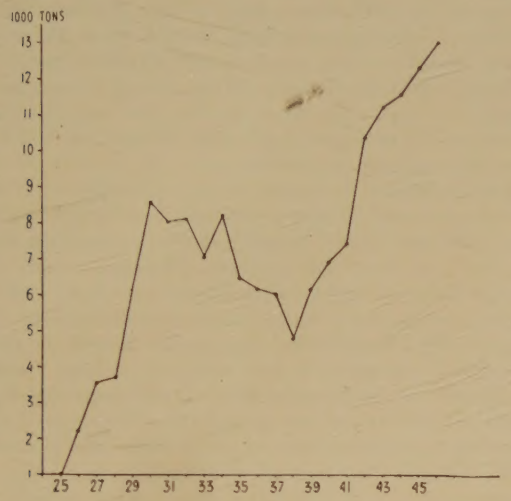

Fig. 1. Product of the Greenlanders' Cod Fishery in the years 1925—1946, in tons.

With regard to East Greenland, Johs. Schmidt (1931) noted the occurrence of the cod at Angmagssalik, and Ad. S. Jensen in 1939 gave information regarding the occurrence of the cod in this district in the later years. According to this the cod had been unknown there until 1912, when some few specimens were taken. From about 1920 it began to occur in small shoals, from 1923 it was fairly common and from about 1930 it was found almost everywhere in the district, especially in the inner parts of the fjords. In the winter of 1930—31 it was abundant in most of the district. Since then the cod has occurred regularly each year in the summer and autumn at Angmagssalik and was caught by the Greenlanders for their own use, no salting of the cod being undertaken in this district.

The quantities of cod taken by the Greenlanders and turned into saltfish are indicated in the accompanying graph, Fig. 1, which shows the yield of cod in unprepared condition for the whole of Greenland in the years 1925—46.

It will be seen how the fishery from a small beginning suddenly rose in the middle twenties and reached a peak provisionally in 1930 with a yield of over eight thousand tons. In the following years the yield was somewhat variable. It was very low especially in 1938 which was an unusually cold year with stormy weather, thus greatly interfering with the fishery. In 1939 the yield was again up to normal.

In the war years the product of the cod fishery by the Greenlanders was very large. In 1942 it exceeded ten thousand tons and in 1946 it reached the record of thirteen thousand tons.

It will be seen from the curves, Fig. 2, which show the yield of the fishery in the districts of Julianehaab, Sukkertoppen and Egedesminde, that the Egedesminde district, which in the beginning had a lower yield than the others, has had the highest since 1943. Thus, in recent years the fishery has given a larger yield in the northern districts than in the southern. The great and sudden rise of the Greenland cod fishery in the middle of the twenties was due especially to the occurrence of large year-classes, a condition that will be discussed in more detail in the section on the fluctuations of the year-classes in the stock of Greenland cod.

The length of the fishery season and its culmination are very different in the different districts. In the southern districts there is a long season with fairly even yield for several months, whereas in the northernmost districts where a fishery is carried on, the season is very short. In 1946, for example, fishing could be carried on at Julianehaab, Frederikshaab,

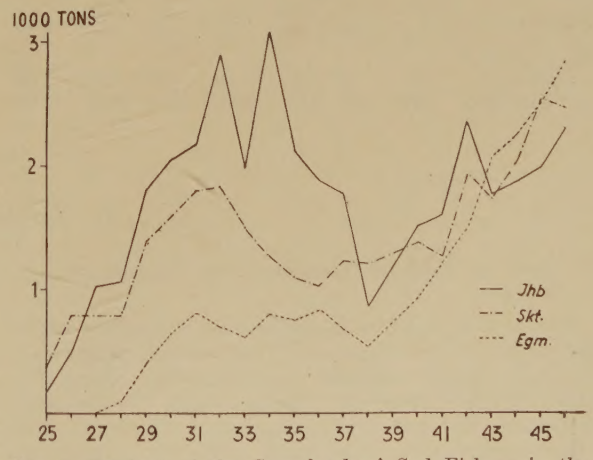

Fig. 2. Product of the Greenlanders' Cod Fishery in the districts of Julianehaab, Sukkertoppen and Egedesminde in the years 1925—1946, in tons.

Godthaab and Sukkertoppen from May till October, and April has also given a small yield. In these districts the fishery has given the largest yield in July. In the same year the fishery in the Egedesminde and Jakobshavn districts has extended from July till October

with a minimum yield in June. August has given here by far the largest yield.

In the winters of 1946—47 and 1947—48 the cod have been found in all the South Greenland districts from Julianehaab up to and including the Sukkertoppen district. Some quantities have been dried in these winters, but no cod were salted owing to the frost.

The very great occurrence of the cod in Greenland waters must be viewed from the background of the considerable change in the natural conditions, temperature and marine currents, which has taken place there from the beginning of the twenties. Several papers have dealt with this condition (HANSEN, JENSEN, TÅNING 1935), (JENSEN 1939 and 1944) to which reference may be made. The warmer conditions in the sea have led to several marine forms, previously with a southern distribution, extending their area northwards in the Greenland waters, whilst more arctic forms have retreated farther north. This change in the occurrence applies to the invertebrates as well as to fish and marine mammals (see pp. 14—15). The warm period has now lasted over twenty-five years and there is still no sign that it is about to end.

As the cod fishery gradually developed the Greenland Administration set up more and more stations for the salting of cod. In the report of the Greenland Administration No. 1, 1944, summary of the statistical information regarding Greenland III, p. 659, an account is given of the fish-houses erected in West Greenland. From this we have the following:

Table 1. Fish-Houses in West Greenland.

Year.....	1910 —14	1915 —19	1920 —24	1925 —29	1930 —34	1935 —39	Total
No. of houses erected....	11	3	24	21	52	14	125
m.² floor area	725	129	1506	1077	3134	1104	7675

Among these are reckoned fish-houses for the Greenland halibut, but this means only a few houses, as the fishery and treatment of the Greenland halibut are restricted to Jakobshavn and the Julianehaab district. Some of the houses are also used for the salting of sharks' skins and a few of them have changed to other uses, whilst several have been extended. In 1939 there were in all 115 fish-houses, 75 in South Greenland and 40 in North Greenland. During the war and since more new and spacious fish-houses have been built and several of the old have been greatly extended.

Just as along the coast large quantities of cod appeared on the off-shore banks in the Davis Strait and at the same time, though in earlier periods scarcely any cod had been found there. Fishing vessels belonging to many different nations have been fishing on the banks each summer since the middle of the twenties. The Norwegians began this fishery in 1924 after the Norwegian Arctic skipper JOHAN OLSEN had discovered large quantities of cod on the banks in Davis Strait in the summer of 1923 (DEVOLD 1947). According to information received from the International Council the yield of this fishery has been as follows:

Table 2. Yield of the Fishery on the off-shore Banks in the Davis Strait.

	Tons		Tons		Tons
1925...	352	1930...	43,060	1935...	38,232
1926...	2,502	1931...	51,053	1936...	61,553
1927...	3,114	1932...	36,603	1937...	48,459
1928...	1,808	1933...	18,038	1938...	47,069
1929...	14,312	1934...	45,713		

During the war there was practically no fishing by foreign countries in Greenland waters, with the exception of some Portuguese vessels.

II. Environment.

A. Hydrographical Conditions in Greenland Waters.

The hydrography of the Greenland waters has been the object of investigations by several expeditions; of these special mention may be made: "Ingolf" 1896, "Tjalfe" 1908—09, "Dana" 1925, "Godthaab" 1928 and the American expeditions "Marion" and "General Green" in 1928, 1931, 1933, 1934 and 1935. In addition, hydrographical observations have occasionally been made by the Danish inspection vessels, whilst the small research vessels of the Greenland Administration have made observations especially in the coastal and fjord areas. The available observations are unfortunately somewhat scattered and we lack especially continuous observations throughout the year over a long period.

It has been possible nevertheless to obtain a view over the main tendencies of the hydrographical conditions. A survey has been given by KIILERICH (1943) and this has been followed in the main here. During the war DUNBAR made some hydrographical observations especially at Godthaab (DUNBAR 1946). SMED has noted the variations of the surface temperature in Greenland waters over the period 1876—1939 (SMED 1947).

The Greenland waters come under the influence of the cold East Greenland Polar Current on the one side and of the warm Atlantic Irminger Current on the other. The Polar is a surface current coming from the Greenland Sea and the Arctic Sea; it runs close to the East Greenland coast. After rounding Cape Farewell it turns northwards along the coast of West Greenland. At Cape Farewell the temperature early in the summer is negative across almost the whole

breadth of the current; later, it may rise right up to 2°—4°; the salinity is 32—34 ‰. The Irminger Current is a branch of the North Atlantic Current. It washes the coast of West Iceland, then turns west and follows the Polar Current outside the shelf. At a depth of 200—400 m. the nucleus of this current has a temperature of 4°—5° and a salinity of 34·75—35·00 ‰. Later in the summer the temperature rises one or two degrees, whilst the salinity falls slightly. The two streams gradually mix with each other east of Cape Farewell and with subarctic water which flows out from the western part of the Davis Strait. The water masses occurring at the southernmost part of East Greenland and along West Greenland are in great part mixed water. On the west coast the Polar Current is strongest at Cape Farewell and is only present on the southern banks, where in certain years it can be detected on the slope of the banks at a depth of about 100 m. It increases in volume about midsummer and may sometimes overflow the banks. In other summers with small volume it can hardly be detected, and in specially warm years the Polar Current may itself be warm and the temperature may rise evenly over the banks in the south up to 4°—5° C. The Polar Current spreads along the southern side of Lille Hellefiske Bank and thus has no influence on the hydrographical conditions of the northern banks. It continues towards the west where it mixes with the cold, south-going Canadian Polar Current from Baffin Bay, farther south called the Labrador Current. From experiments with drift bottles it has been shown (Hermann and Thomsen 1946), that their rate of drift was strongest near Cape Farewell, decreasing considerably northwards. For example, at the southernmost part of West Greenland an average drift of 11 sea-miles in 24 hours was observed, whereas to the north around 68° the drift was less than 1 mile.

The Polar Current is strongest as a rule in the first part of the summer, slacking off generally before the middle of August. While the southern banks are under the influence of the Polar Current, this current is not felt over the Store Hellefiske Bank. According to Kiilerich the weak north-going current over these banks consists mainly of local mixed water. The warm Irminger Current appearing as an undercurrent reaches a maximum in the autumn or later in the winter. It then penetrates into all the deep fjords, even where there is a threshold at the mouth, and perhaps over the banks.

In May—June before the currents make their appearance, the temperature over the southern banks may amount to 0—1° and the salinity to 33·50—34·00 ‰; in warm years the temperature may rise to 2°. Over the northern banks at this time there may often be cold, winter-cooled water (temperature 0— —1°, salinity ca. 34·00 ‰), which however soon becomes warmer when the winter ice and west ice disappear. At greater depths, 400—700 m., to the north we often find a warm water layer with a temperature of 1—5°, originating from the warm current of the previous year. In warm summers the surface water down to 50 m. over the northern banks may have a temperature of 4—6°, when the temperature at ca. 100 m. is about 1—2° as a rule. The cold south-going Canadian Current on the west side of the Strait may sometimes extend as far to the east as to the edge of the Store Hellefiske Bank at a depth of 100—200 m. and thus may prevent the inflow of warm water.

The temperatures over the banks are thus dependent on which of the two main currents, Polar and Irminger, is the strongest. Great variations are apparent in the hydrographical conditions. Warm and cold periods have succeeded each other. It would appear that the eighties of last century had a warm period, replaced however by a cold at the beginning of this century. In the twenties again a markedly warm period sets in which still continues. It reached its peak in 1934, a very warm year. 1938 again was unusually cold. In that year large quantities of dead fish of various species, e.g., cod, catfish and Norway haddock, were stranded at Sukkertop; in the spring at Holsteinsborg the prawn fishery with trawl brought up large quantities of dead cod (Hansen 1939) (Ad. S. Jensen 1939, pp. 73, 74). 1939 was again a year with higher temperatures in the sea.

Smed (1947) from a study of the surface temperature over the period 1876—1939 has shown, that the records indicate a considerable increase in the beginning of the twenties, and the high temperatures continued till 1939 with exception of the year 1938, when they were very low. In agreement with the increase in temperature is the fact that the air temperature increased greatly. According to Scherhag (1937) the temperature increase was due to an increased atmospheric circulation in recent years. In the war years Dunbar (1946) made hydrographical observations especially at the mouth of Godthaab Fjord and came to the conclusion, that the warm period was about to end; this was based on the lower temperatures found in the period 1942—44 in conjunction with much winter-ice in the winters of 1943—44 and 1944—45 as well as the occurrence of "Storis" at Godthaab in August 1945. On the other hand, observations from the research vessel "Adolf Jensen" have not indicated any decrease in the sea temperatures in 1946—47.

It is evident that the increase in the sea temperatures, which has taken place in Greenland waters in recent years, has produced better conditions for the cod, to the extent that it has been able to spawn there. On 10. August 1946 a hydrographical section was taken from Fiskenæs towards the SW. out over the north point of the Dana Bank. The observations were made by Cand. mag. Frede Hermann and the results are shown in Fig. 3. At the request of the present author the material was worked up by Mag. scient. Alf Kiilerich and his conclusions read as follows. "The Polar Current along the outer side of the Dana Bank has obviously been weak and by this time, 19. August, cannot be detected. The Atlantic Current extends outside the bank on the surface throughout the whole section and at some depth shows tempera-

tures and salinities of the same magnitude as at the end of July 1928, but in that year the Polar Current was still, thus three weeks earlier, so broad that in the uppermost 100 m. it reached beyond the bank. If we can imagine that this current in 1928 was forced back behind the bank in the course of August, the conditions in the two years 1928 and 1946 might be considered almost the same off Fiskenæs, both being warm years when all the water masses were warm.

The year 1946 does not seem however to have been on a level with 1934 and 1936, when the Atlantic Current off the Fylla Bank was unusually strong. In 1937 the Polar Current was dominant off that bank in the course of the summer down to a depth of 150 m., but at 300—600 m. the 1937 temperature and salinity were slightly higher than in 1946. In 1938, however, the Atlantic Current kept far out during the whole summer, so that this summer may be said to have been much colder than 1946.

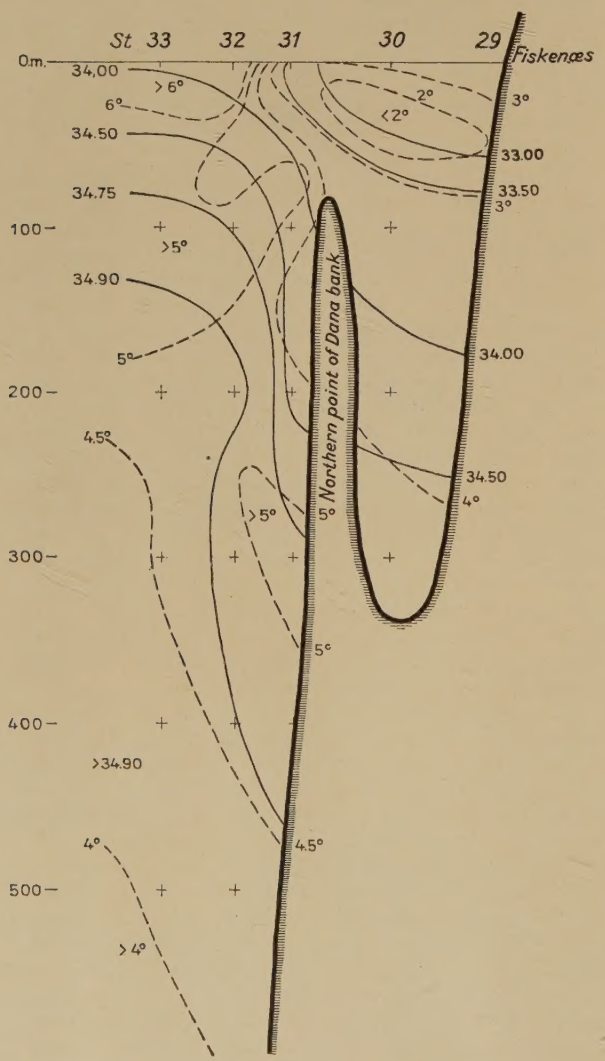

Fig. 3. Hydrographical Section over the northern edge of the Dana Bank on 19.8.1946.

According to the hydrographical observations off Fiskenæs the summer of 1946 was a warm summer, fitting in well with the last twenty years. The summer may especially be called warm, because the Polar Current did not reach beyond the bank (19. August). It is inferior, however, to 1934 and 1936 both in the upper and deeper layers, almost on a level with 1928 and far above 1938 with regard to the importance of the Atlantic Current. It greatly resembles 1924 (Fylla Bank), which was the first warm year".

A survey of the hydrographical conditions in the fjords of Southwest Greenland has been given by J. N. Nielsen (1928). They come under the influence of the current and temperature conditions in the Davis Strait. Another factor in their hydrography is, whether they are deep right out to the open sea or separated from the latter by a threshold which hinders the free passage of the water masses into the deeper parts of the fjord.

In the southernmost parts of Greenland, where the Polar Current is strongest, the water masses from this current will form the upper layers of water in the fjords. Owing to the warmer conditions there, however, the water will be heated quickly unless there is a thin surface layer from the rivers which flows so

Table 3. Temperature Observations in Tasermiut Fjord.

A. May and June.

Year	1894	1932	1947
Date	29·5	21·6	28·6
Depth m.	C°	C°	C°
0	2·5	5·4	6·8
10	—0·8	1·3	3·7
20	—0·7	—	—
25	—	0·59	1·44
50	—	0·46	1·59
60	—0·8	—	—
70	—	—	—
100	—0·9	0·25	1·45
130	—	—	—
200	—	0·32	1·36
300	—	—	1·12

B. August and September.

Year	1894	1934	1938	1939	1946
Date	16·8	21·8	9·9	25·8	9·9
Depth m.	C°	C°	C°	C°	C°
0	6·0	4·8	4·2	6·7	4·62
10	0·1	2·9	2·48	2·5	3·48
25	—	2·6	1·25	1·93	2·62
50	—0·7	1·6	0·81	1·78	1·12
70	—0·6	—	—	—	—
100	—	2·05	0·63	1·57	0·56
125	—	1·5	—	—	—
130	—0·8	—	—	—	—
175	—	—	—	0·43	—
200	—	—	—	—	0·10
250	—	—	—	—	—0·14
325	—	—	—	—	—0·17

rapidly out of the fjord, that it is not able to heat the layers below. In fjords with a threshold only the water of the Polar Current can penetrate early in the summer, whereas the deep fjords without threshold allow the warm, deeper lying Atlantic Current to enter towards the autumn when the warm current is at its strongest. In the years when the Polar Current has been warm, the temperatures in these fjords have been relatively high. Temperature measurements in the two fjords Tasermiut and Lichtenau are given in Table 3, to exemplify these conditions.

In Tasermiut MOLTKE (1896, p. 110) gives the measurements taken in May and August. The present author has made the temperature observations in this fjord in recent years.

It will be seen that, whilst in 1894 there was a very thick layer of negative water which in May reached almost right up to the surface and in August to ca. 50 m., no negative temperatures have been found in recent years except in 1946, when the bottom water was negative. A marked increase of the temperature has thus taken place and this may be ascribed to the higher temperatures of the water which has penetrated into the fjord from outside.

In Tunugdliarfik, at the beginning of August 1909, NIELSEN found a surface temperature of 8°, but the surface layer was quite thin. Under this came a water layer almost 100 m. thick with a temperature of ca. 0·3°. The bottom temperature was however about 2°.

In recent years the following temperatures have been measured:—

Table 4. Temperature Observations in Tunugdliarfik.

Year	1932	1946	1947
Date	4·6	19·9	10·7
Depth m.	C°	C°	C°
0	4·25	2·68	9·5
10	0·59	0·23	8·47
25	0·33	0·09	2·32
50	0·08	0·58	1·92
100	−0·13	0·16	1·90
170	—	1·84	—
200	1·70	—	2·35
350	—	—	2·62

The temperatures in this fjord are extremely variable. The measurements for 1932 and 1946 differ little from NIELSEN's recordings in 1909, but in 1947 the temperatures are considerably higher.

From the Lichtenau Fjord we have temperature measurements for several years, many taken at the same time of year. The temperatures for 1909 were taken by the "Tjalfe" Expedition, in 1946 by FREDE HERMANN and in the other years by the present author.

The temperatures in this fjord have also been extremely variable, yet it is evident from the observations, which were made in the month of August, that

Table 5. Temperature Observations in Lichtenau Fjord.

Year	1909	1932	1938	1939	1946	1932	1947
Date	22·8	15·8	12·8	18·8	4·9	22·6	25·6
Depth m.	C°	C°	C°	C°	C°	C°	C°
0	3·85	9·35	9·5	7·6	8·01	5·35	10·2
10	1·45	3·85	1·56	3·85	3·13	1·36	7·54
25	0·52	2·49	0·87	2·87	2·52	0·61	1·87
50	0·62	1·35	0·63	1·38	−0·62	0·06	1·52
100	0·07	1·53	−0·13	0·72	0·50	0·35	1·75
175	—	—	—	0·93	—	—	—
200	0·61	1·14	0·18	—	1·54	1·20	1·70
300	0·59	—	—	—	—	—	2·08
390	0·58	—	—		—	—	—
400	—	—	—	—	2·66	—	—

all years except 1938 show higher values than 1909. Except in 1909 the surface layer is fairly warm and the salinity low; this comes from the addition of river water. The upper layer down to ca. 100 m. must come from the Polar Current, more or less mixed with Atlantic water. The uppermost layer has been heated by the air. The warming process has not penetrated to 50—100 m. The lowermost layer is fairly warm and in recent years considerably warmer than in 1909. This has been caused presumably by the penetration of Atlantic water in the preceding autumn. The years 1938 and 1946 are the only ones to show negative temperatures in the water. In 1938 this occurred at a depth of 100 m., in 1946 at 50 m. In 1938 the bottom water was cold, 0·18° at 200 m., but it was comparatively warm in 1946, which points to a stronger inflow of polar water in 1938 than in 1946. Its fairly high salinity in 1946, 33·98 ‰ at a depth of 400 m., indicates a preponderance of Atlantic bottom water in that year.

Turning now to the Godthaab Fjord we find that the conditions during the present warm period have changed even more than in the southern fjords, especially in the inner parts of the fjord.

Some of the temperatures observed in this fjord are given in Table 6. The observations in 1908 were made by J. N. NIELSEN, those of 1946 by FREDE HERMANN, in 1943 by DUNBAR, the remainder by the present author.

In 1908 the temperatures at the mouth of the fjord lay below 1° in all layers of water, whereas in the later years no temperatures below 1° were found. The temperatures are thus far higher in recent years than in 1908. Turning to the observations inside the fjord we find an even more marked difference between 1908 and the later years. On station 27 of the "Tjalfe" Expedition in the sound off Kornok negative temperatures were found from 75 m. to 250 m.; in the later years negative temperatures have not been found anywhere in the fjord area.

Comparing the observations for the years 1946 and 1947 with those from the thirties in the same months we do not find any great differences. There seems nothing to indicate, that the warm period is about

Table 6. Temperature Measurements at Godthaab Fjord.

A. At the mouth of the Fjord.

Year.....	1908	1947	1935	1934	1946	1947	1943
Date.....	20·6	31·5	11·6	5·7	15·7	1·8	28·10
Depth m.	C°	C°	C°	C°	C°	C°	C°
0.....	0·75	3·95	4·35	5·0	7·81	8·0	0·96
10.....	—	3·80	3·62	3·65	6·09	4·27	1·06
25.....	0·60	2·81	2·65	3·67	3·71	3·72	—
50.....	0·62	1·89	2·0	3·27	2·61	4·70	2·45
100.....	0·58	1·77	1·31	2·82	2·11	3·05	2·75
200.....	0·61	1·80	1·14	2·52	1·45	2·55	—
300.....	—	1·70	1·10	2·49	1·35	2·28	3·25
350.....	—	—	—	—	—	—	—
385.....	0·54	—	—	—	—	—	—
400.....	—	1·94	—	—	1·32	2·47	—

B. Inside the Fjord.

Year.....	1933	1936	1939	1947	1926	1938	1946
Date.....	25·5	24·5	15·6	2·6	7·7	9·7	27·7
Depth m.	C°	C°	C°	C°	C°	C°	C°
0.....	3·9	2·8	6·2	7·1	8·59	8·3	4·73
10.....	1·05	2·16	5·38	6·48	8·93	4·74	1·45
25.....	1·02	2·00	2·48	4·3	2·25	1·17	2·44
50.....	1·40	1·92	1·13	2·08	2·60	1·67	2·62
100.....	0·86	1·92	0·94	2·43	2·30	1·28	2·00
200.....	0·67	1·38	0·79	2·14	1·73	1·20	1·40
250.....	—	—	—	2·08	—	—	—
300.....	—	—	—	—	1·21	1·47	1·35
400.....	—	—	—	—	—	2·42	1·94

to end. It looks rather as if the temperatures, especially in the deeper layers, are on the whole a little higher than the earlier years' observations show.

During the investigations of the "Tjalfe" in 1908 practically no cod were taken in Godthaab Fjord, which is not surprising when we consider the hydrographical conditions. In the warm period, on the other hand, large quantities of cod were present everywhere in the fjord.

B. Hydrographical Conditions and Spawning of the Cod in other North Atlantic Regions compared with Greenland.

We may now consider quite briefly the hydrographical conditions in various other regions where the cod occurs. A short summary of the hydrographical conditions at Newfoundland is given by Thompson (1943, pp. 94—96). The region is under the influence of the cold, south-going Labrador Current coming from Baffins Bay. It flows along the east coast of Newfoundland in February and sends a branch into the strait at Belle Isle. It has a breadth of 10—20 miles and reaches down to ca. 450 m.; its rate of flow is from 12—14 miles per day and its temperature is from 0—3° C. To the south of Newfoundland it mixes with warm oceanic water. The cold stream shows great variations in different years; strong in 1932, 1933 and 1935, whilst 1930 and 1934 were very warm years. The region is characterised by greatly varying temperatures.

An excellent survey of the hydrographical conditions in Icelandic waters has been given by Thomsen (1938). The south coast is washed by the warm Atlantic Current, which sends a north-going branch, the Irminger Current, up along the west coast, whilst the north and especially the east coast come under the influence of the polar water. A small part of the Irminger Current, however moves north round the island and the northern part of the east coast. On the south coast the temperatures are high in the surface water all through the year. In February, when there is a minimum, the surface temperature is about 6° C.,

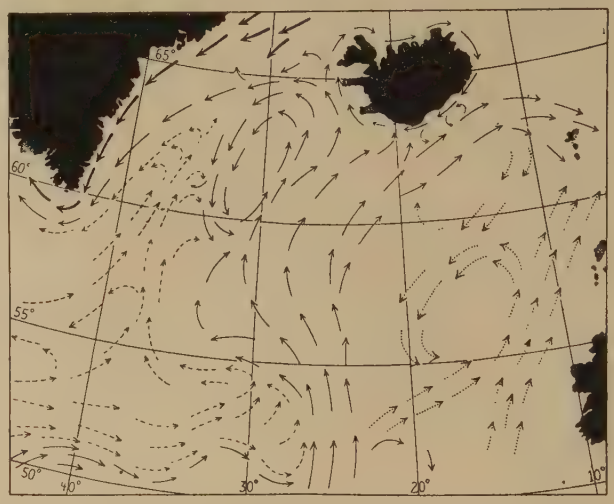

Fig. 4. Currents in the northern Atlantic. Thick unbroken arrows: polar water; thin unbroken arrows: Atlantic water; broken arrows: sub-arctic water; dotted arrows: hypothetical course of currents in the eastern Atlantic. (Prepared by F. Hermann.)

but in July—August it mounts right up to about 11° C. On the west coast it is about 2° C in February and over 8° in July—August. At the bottom the temperature in April is 5°—7° on the south and south-west coasts, but 1°—2° on the east and north coasts; on the north-west coast the temperature is 2°—3°. In May—June the temperature rises to 7°—9° on the south coast and 1°—4° on the north coast. In August the temperature is 7°—11° and 6°—9° on the south and north coasts respectively.

The cod marking experiments in Greenland waters (Hansen, Jensen and Tåning 1935) have shown, that the great majority of the recoveries at Iceland of cod marked at Greenland have been made in the spring on the south-west and west coasts of Iceland. The surface temperatures here lie between ca. 2° and 7° C in March and between 5° and 8° C in May; consequently, the conditions for spawning and hatching of the cod may be considered much more favourable here than at the lower temperatures which may occur in the Greenland waters at the same time of year. The cod young are carried by the currents

Fig. 5. Currents in the waters west of Greenland. Thick unbroken arrows: polar water; thin unbroken arrows: Atlantic water; thick broken arrows: mixed coastal and sub-arctic water: thin broken arrows: sub-arctic water. (After KIILERICH, 1943, simplified.)

to the north and east coasts, and it has been shown (TÅNING 1937 and 1943) that they may at least in certain years transport the young over towards Greenland. As at Greenland a considerable rise of the sea temperature has been noted in recent years at Iceland, as also changes in the occurrence of various animal forms (SÆMUNDSSON 1934, THOMSEN 1932). So far as the cod is concerned, it has been found to spawn on the north coast, a condition not found in earlier years. The year 1939 especially showed very high temperatures and in July—August a greater drift of the cod and haddock fry was observed than had ever been noted before. The sizes of the pelagic cod fry were greater than is the case normally for the time of year (TÅNING 1943, p. 76).

At Spitzbergen the sea temperatures are very low. The water masses often have negative temperatures from the surface to the bottom. The warm Atlantic Current, the main portion of which runs along the north coast of Norway, sends a branch strongly mixed with cold water past the western side of the group of islands. There have been periods when cod occurred and a cod fishery has been carried on by the Norwegians from 1873 to 1882. Then a break of several years occurred in the fishery. From 1923 some investigations were again made by the Norwegians and good catches of both cod and haddock were made. IVERSEN (1933) showed that spawning of the cod occurred at Spitzbergen and small cod of the I, II and III-groups were found, so that the cod also grows up there. IVERSEN is of the opinion, however, that there is so little spawning that it can be of no importance for the stock; the area must have some connection with the spawning banks of the cod off the coast of Norway.

A branch of the warm Atlantic Current flows along the Norwegian coast and the temperature of the water is fairly high all through the year. The main spawning places of the cod lie at the Lofotens; from Finmark the cod migrate there to spawn in January to March. The fry are then carried northwards with the north-going current and grow up in the Barents Sea, where the young age-groups of the "Skrei" are taken in deeper water. The codling found near the coast belong to the coastal cod.

The Faroese area is controlled on the one hand by Atlantic water, which comes from the south and flows up along the west side of the islands, on the other by the cold Polar Current from East Iceland which flows north-east of the islands. The tides are very strong, producing a great mixing of the waters so that the temperatures vary but little. These are somewhat lower than in the Norwegian waters in the same latitudes, but are nevertheless fairly high. The mean temperature for the coldest month is ca. $5^1/_2°$ and for the warmest ca. $10^1/_2°$.

Fig. 6. The currents of the Norwegian Sea. (From HELLAND-HANSEN.)

The cod spawn at the Faroes from the end of February to the beginning of May at a temperature of 6°—7°. The principal spawning grounds lie in the Norwegian Sea north of the islands, and in the Vaagø Sea to the west. In addition there is a scattered spawning at other places in the area, as also on the Faroe banks. The young fry are dispersed very rapidly over the whole area by the strong currents. Marking experiments have shown, that there is but little emigration of the Faroese cod to other areas, namely, one to the Orkneys, one to the northern part of the North Sea and one to Bear Island; similarly only three cod have been recaptured which were marked in other areas, namely 2 from Iceland and one from West Greenland. The Faroese area is thus self-sustained, so far as the cod is concerned.

At Norway, Iceland and the Faroes, where warm currents prevail, we find local stocks of cod with their main spawning grounds in the areas. In the first two areas the fry are carried by the currents northwards and grow up in areas with colder water. The spent cod scatter again in the more northern areas. On the other hand, Spitzbergen has less favourable hydrographical conditions; its stock of cod depends entirely on imports from Norway. The stocks of cod at the southern parts of West Greenland and at Angmagssalik on the east coast have a connection with Iceland, their spawning grounds being at south-west and south Iceland, whence the fry are carried back to Greenland and grow up there. The stock of cod in middle-west and north-west Greenland may be considered for the most part to spawn in the Davis Strait between 63° and 66°50′ N.L.; from there some of the young are carried up to North Greenland were growth takes place. Presumably some portion of the young also comes from spawning places in the fjords. Nothing is known as to whether the drift of fry from Iceland is of any importance for the more northerly districts. As will be shown in dealing with the migrations, there is also an emigration of spawning cod to Iceland from the northern areas, but to a much smaller extent than from the two southernmost districts.

South Greenland and Iceland thus stand in the same relation to each other as Finmark to the Lofotens, or as North and East Iceland to the waters round the Westmanna Islands.

C. Changes in the Marine Fauna at Greenland in Recent Times.

Great changes in the fauna have taken place during the warm period which has ruled in Greenland waters since the twenties. In addition to the large immigration of cod many southern forms have appeared, which previously did not occur there or only rarely. On the other hand, several arctic forms have retreated farther north. Some idea of these changes has been given by Hansen, Jensen and Táning (1935, pp. 13—15) and in more detail by Jensen (1943). These papers may be referred to and mention made here of further observations since they were published.

On 12th June 1947 during fishing with the prawn-trawl in Skovfjord, Julianehaab district, at 365 m. a **blackmouth** (*Gadus poutassou*) of 21·5 cm. was taken. This fish had never before been caught at Greenland. It occurs from Finmark and Iceland to Gibraltar and the Mediterranean. It spawns in the open ocean along the edge of the Continental Shelf. At Iceland it was taken for the first time in 1899, but it has proved to be common on the south and south-west coasts, though not known from the north and east coasts (Sæmundsson 1909 and 1927).

The **coalfish** (*Gadus virens*), which began to appear at several places along the coast and in the fjords when the warm period set in, occurs constantly at Greenland. Seven coalfish were taken in an eel-seine on 30. August at Kadlumiut in the inner part of the Lichtenau Fjord in the Julianehaab district, they measured from 20—25 cm. and belonged to the II-group.

The **haddock** (*Gadus aeglefinus*), also one of the fishes occurring in recent years, was taken for the first time in 1929 at Sydprøven. Later, it has been taken at several places right up to Holsteinsborg (Jensen 1939). In 1945 Vibe notes that it is frequently taken in the cod fishery (Grønlandsposten 1945, No. 1, p. 5). Porsild mentions a catch of haddock at the settlement in Disko Fjord, 69°30′ N.L., on October 14. 1944 (Grønlandsposten 1945, No. 17, p. 240). This is the northernmost locality where the species has been caught at Greenland. In 1947 a haddock was caught at Ikamiut (ca. 68°38′ N. Lat.) in Christianshaab district.

The **torsk** (*Brosmius brosme*), earlier an extremely rare fish at Greenland, was taken according to Jensen (1939, p. 14) in the Ikertok Fjord in 1936 and on 11. September 1937 at Narssak in the Julianehaab district (not Narssalik, as given by Jensen). Again, on 5. September 1939 a torsk was taken on long-line in the inner part of Lichtenau Fjord. In 1946 a specimen was taken in Lichtenau Fjord on 14. September almost at the same place as the species was taken in 1932 in the prawn-trawl at a depth of ca. 250 m. Porsild (Grønlandsposten 1945, No. 17, p. 240) mentions a catch of torsk in the Umanak Fjord, ca. 70°40′ N.L. This is the most northerly place where the species has been taken at Greenland. Of both haddock and torsk it may be said, that they are not species which live in specially warm water but simply forms which have not previously occurred in West Greenland waters and have now extended their range there.

The **fjord cod** or ogac (*Gadus ogac*), earlier an abundant fish on the coast and in the fjords at West Greenland, now occurs in very small numbers in the warm period, having moved farther north. In experiments with the long-lines in Lichtenau Fjord in 1929, 1930 and 1932 only a few isolated ogac were taken. In 1938, which was a very cold year, it was taken in fairly large numbers in the long-line fishery of the Lichtenau Fjord, in 1939 again it was also taken there in large quantities. In 1946 and 1947 when fishing with the prawn-trawl was carried on at the same places in the Lichtenau Fjord no ogac were taken.

Thus it seems to have disappeared again from this fjord.

The **witch** (*Pleuronectes cynoglossus* L.) had previously been taken by the "Dana" in 1925, only two specimens with the otter-trawl on the edge of the Lille Hellefiske Banke. With the prawn-trawl it was taken both in 1946 and 1947, in the Lichtenau Fjord on 14. September at 250 m. and in Skovfjord on 15. June at ca. 350 m. The first specimen was a full-grown female of 34 cm., the second a young fish of 95 mm. The distribution of this species extends from the Murman Coast and Iceland to the Bay of Biscay. In America it occurs down to Cape Cod. At Iceland it was previously not known from the north coast. Its northern limit was Djupall off Isafjord Deep. It was taken for the first time at North Iceland in May 1926 on the outermost edge of Stranda ground (240—250 m.) and in May 1931 other three specimens were taken on the Skaga ground farther east. SÆMUNDSSON (1934) is of the opinion that its occurrence there was due to a rise in temperature of the sea.

The **halibut** (*Hippoglossus vulgaris*) spread right up to Upernavik towards the end of the thirties, according to LUND-DROSVAD it has constantly been taken in this district during the forties.

The young of the **Norway haddock** (redfish — *Sebastes marinus*) were not found in the Davis Strait by the "Tjalfe" in 1908 and 1909, but it was common in the Denmark Strait. AD. JENSEN (1922) concluded from this, that the large pelagic young found at West Greenland came from fry carried over by the current from the Denmark Strait. On the other hand, both the "Dana" in 1925 and the "Godthaab" in 1928 obtained large numbers of the tiny fry of the Norway haddock in the Davis Strait as far up as the submarine ridge, which extends from about the latitude of Holsteinsborg right across the Strait to Cumberland. In the Greenland fjords only two small fry of the Norway haddock had earlier been taken with the 1 m. ring-net, namely in Tunugdliarfik at the beginning of June 1933. In 1947 several specimens of the young Norway haddock were taken by the ring-net in Tunugdliarfik about the middle of June, at the end of May in the same year the fry of the Norway haddock were taken in Godthaab Fjord.

On 2. June 1947 two Norway haddock were caught in Pisigsarfik in the Godthaab Fjord, they were caught in the prawn-trawl at 260 m. and both measured 44 cm., both were in full spawning. The Norway haddock has thus begun to spawn in the Davis Strait and recently also in the fjords of south-west Greenland.

The **herring** (*Clupea harengus*) has always been present along the coast, especially in the districts of Julianehaab, Frederikshaab and Sukkertoppen. During the whole war years the herring were fished for salting at Kangerdluarssuk in the Sukkertoppen district. The catches have been so good, that they were in part able to satisfy the demands of the inhabitants.

In 1947 there were reports of larger shoals than in previous years from various parts of the Julianehaab district. Some herring were taken in nets and several barrels salted. From earlier investigations (HANSEN 1934) it appeared that the Greenland herring were probably the same as the summer-spawning herring at Iceland.

The **spotted catfish** (*Anarhichas minor*) has spread far to the north in recent years. The outpost-manager LUND-DROSVAD reported in "Grønlandsposten" 1946 No. 5, p. 115): "The catfish has now reached far to the north and is very abundant in the Upernavik district. In 1943 it was taken for the first time right up to the north of Melville Bay at Savigsivik, on long lines laid out for halibut. At Prøven it had not been known 10 years ago, but it is now so numerous that last year 8,000 kg. could be traded apart from what the inhabitants themselves used."

The **capelan** or lodde (*Mallotus villosus*) had spread right up into the Upernavik district by the middle of the thirties and according to LUND-DROSVAD (1946) had become even more common in this district by the middle of the forties. At Ikamiut it was so abundant that it could be caught in buckets—something that could not be done earlier.

The **piked dogfish** (*Squalus acanthias*) was earlier a great rarety at Greenland, but in the thirties some were caught at several places in the Sukkertoppen district right up to Umanak, though single specimens only. In the autumn of 1947 several were caught round about the Sukkertoppen district according to a letter from the colony-manager BRANDT in Sukkertoppen.

With regard to the **arctic mammals** LUND-DROSVAD (1946) has noted, that the migrations take place later than in earlier years. It was reckoned previously in Upernavik, that the white whale (*Delphinapterus leucas*) arrived about the 10. September. In 1945 it did not appear till the 20. of October, but remained on the other hand the whole of January in to February. The narwhal (*Monodon monoceros*) also migrates much later than in earlier years. In 1947 the Sei-whale (*Balaenoptera borealis*) was observed for the first time in Greenland waters, i. e., seven animals in the Davis Strait off Holsteinsborg district; two of them were captured.

In the case of **invertebrates** we have the discovery of *Mytilus edulis* by mag. scient. CHR. VIBE at Thule in 1939. This mussel had not been known previously so far north. It was not found in this district when the "Godthaab" was working there in 1928. Further, VIBE on the 11. of December 1939 caught two Crustacea with the bottom-sampler at 54 m., namely the prawn *Synalpheus fritsmulleri* Coutiere and the isopod *Nerocila acuminata* Sch. and Mein. Previously these two species had only been known about 40 degrees farther to the south, namely on the east coast of North America from 35°—40° N. to the Gulf of Mexico or more to the south (Brazil) and the West Indies (STEPHENSEN 1947). Their occurrence at Thule is a mystery, it cannot be said whether these forms have reached here in recent years, or whether they have always lived at the place where they were found.

Possibly it is a question of animals which have a much wider distribution than we were previously aware of.

On 30. June 1948 two big specimens of the common starfish *(Asterias rubens)* which, since the middle of the twenties, has been found at various localities from Julianehaab to Holsteinsborg, were caught in the innermost part of the Kangersunek Fjord, near Akugdlît, at ca. 68°50′ N. Lat., which is the northernmost locality where this species has been found.

III. Spawning and Development.

A. Distribution of the Cod Fry in West Greenland Waters.

1. Methods and Gear for the Capture of Cod Fry.

The eggs and postlarvae of the cod are obtained by means of conical canvas nets of various sizes.

The "Dana", "Godthaab" and "Islands Falk" used canvas nets with the opening attached to rings of 2 m. and $1^1/_2$ m. in diameter. Rings of 2 m. in diameter were most frequently used. From motor boats the ring was usually 1 m. in diameter; in a few cases a ring of $^1/_2$ m. was used. The nets of $^1/_2$ m. and 1 m. in diameter were provided with a sieve at the end, closed by a piece of fine gauze kept in place by means of a galvanized ring with a wing-screw. The hauls were made horizontally at slow speed. The duration of the haul has usually been half an hour and the nets have been towed by varying lengths of wire. The "Dana" has made many hauls with much greater wire-lengths and the "Godthaab" has also used greater lengths several times; otherwise the length of wire out was in most cases 100 m. or 50 m., corresponding to an actual depth of approximately 30 m. and about 15 m., respectively. The larger vessels have often used several nets on the wire at one time, thus fishing at different depths. This could not be done from motor boats.

Vertical nets for the purpose of a quantitative estimate of the numbers of fry have not been used. In the Greenland waters the cod fry are so few and scattered, that in most cases practically no cod fry would be captured.

Horizontal hauls with the canvas net can only give an imperfect idea of the quantitative occurrence of the cod fry. It is not certain, that the net has been towed at the same rate in all the hauls, thus fished at the same depth; nor is it certain that the same amount of water has filtered through the net in the same time. Sometimes large quantities of diatoms are entangled in the net, resulting in imperfect filtration. Hence no reliable, quantitative investigation could be made with this apparatus. Under the conditions prevailing however, the canvas net has been the only apparatus that could be used, and on collating the results from the different stations it would seem, that the available material nevertheless permits of a rough comparison.

The number of stations where pelagic hauls were made varied greatly in the different years. Over the banks and the deep parts of the Davis Strait most hauls were made in 1925 when the "Dana" carried out investigations at Greenland. In the coastal and fjord area most hauls were made in 1935 and 1936. Altogether 463 hauls were made in the coastal area, in the period from April to October; the majority (ca. 83 %) in the months of May to July; most of the hauls were made in June (ca. 32 %).

That we have to do with the fry of *Gadus callarias* in the hauls and not with the nearly allied *G. ogac* is made evident in various ways. Some of these have already been mentioned by Ad. S. Jensen (1926, p. 413).

1. The postlarvae agree fully in appearance with the larvae of *G. callarias*.
2. The distribution of the fry at Greenland; maximum in the Sukkertoppen-Godthaab district and very few or no fry in the northern areas where the ogac is abundant.
3. The earlier spawning of the ogac (February—March). It is probable that the ogac, which only occurs at the coast and in the fjords, does not have pelagic eggs which could be carried out to the open sea by the currents, but has bathypelagic eggs. This probability is supported by some investigations made several years ago by the intelligent Greenlander, assistant-bailiff Peter Dalager, at the instigation of the director of the arctic station at Disko, mag. scient. M. Porsild. Dalager searched for the eggs of the ogac in the Disko Fjord and obtained some by sinking a silk-net down to the bottom in fairly shallow water. It was only when the net touched the bottom that eggs were taken. Dalager has shown me drawings of these eggs with embryos and there can be no doubt that they belonged to a Gadoid.

2. Coastal and Fjord Areas.

To give an impression of the distribution of the cod fry near the coast and in the fjords of West Greenland, the whole area has been divided into nine zones as shown in the accompanying chart (Figs. 7—9).

Zone I includes Umanak Fjord, Vajgat and Disko Bay to Egedesminde (68°40′ N.L.).
Zone II from Egedesminde to S. Kangerdluarsuk north of Holsteinsborg (67°00′ N.L.).
Zone III from there to Søndre Strømfjord (66°00′ N. L.).
Zone IV to Kangarsuk north of Napassok (65°15′ N. L.).

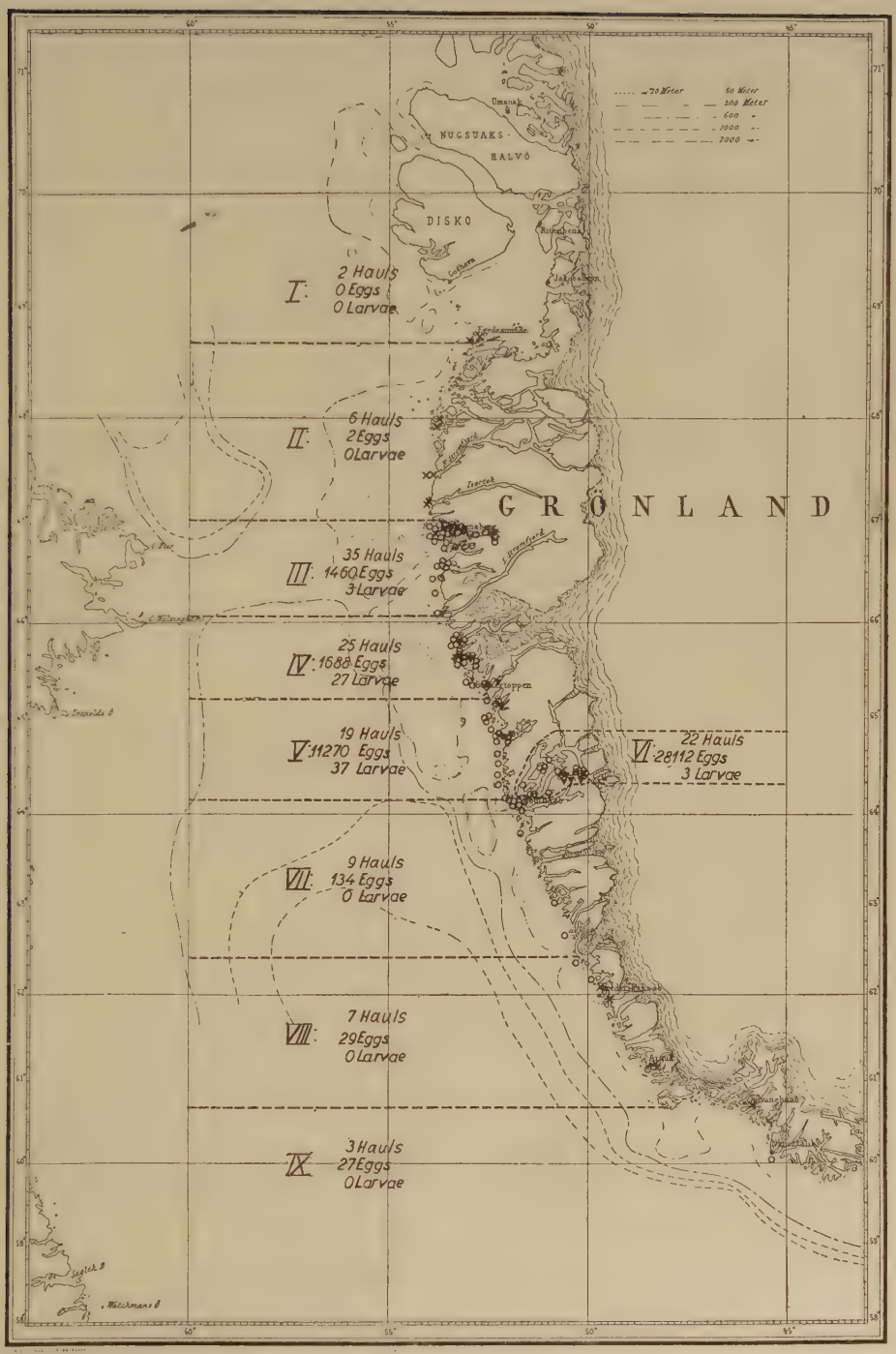
NUGSUAKS-
HALVÖ
DISKO
GRÖNLAND
I: 2 Hauls 0 Eggs 0 Larvae
II: 6 Hauls 2 Eggs 0 Larvae
III: 35 Hauls 1460 Eggs 3 Larvae
IV: 25 Hauls 1688 Eggs 27 Larvae
V: 19 Hauls 11270 Eggs 37 Larvae
VI: 22 Hauls 28112 Eggs 3 Larvae
VII: 9 Hauls 134 Eggs 0 Larvae
VIII: 7 Hauls 29 Eggs 0 Larvae
IX: 3 Hauls 27 Eggs 0 Larvae

Fig. 7. Number of Cod Eggs and Fry in 10 hauls of half an hour each with the 1 m. ring-net, at West Greenland in May.

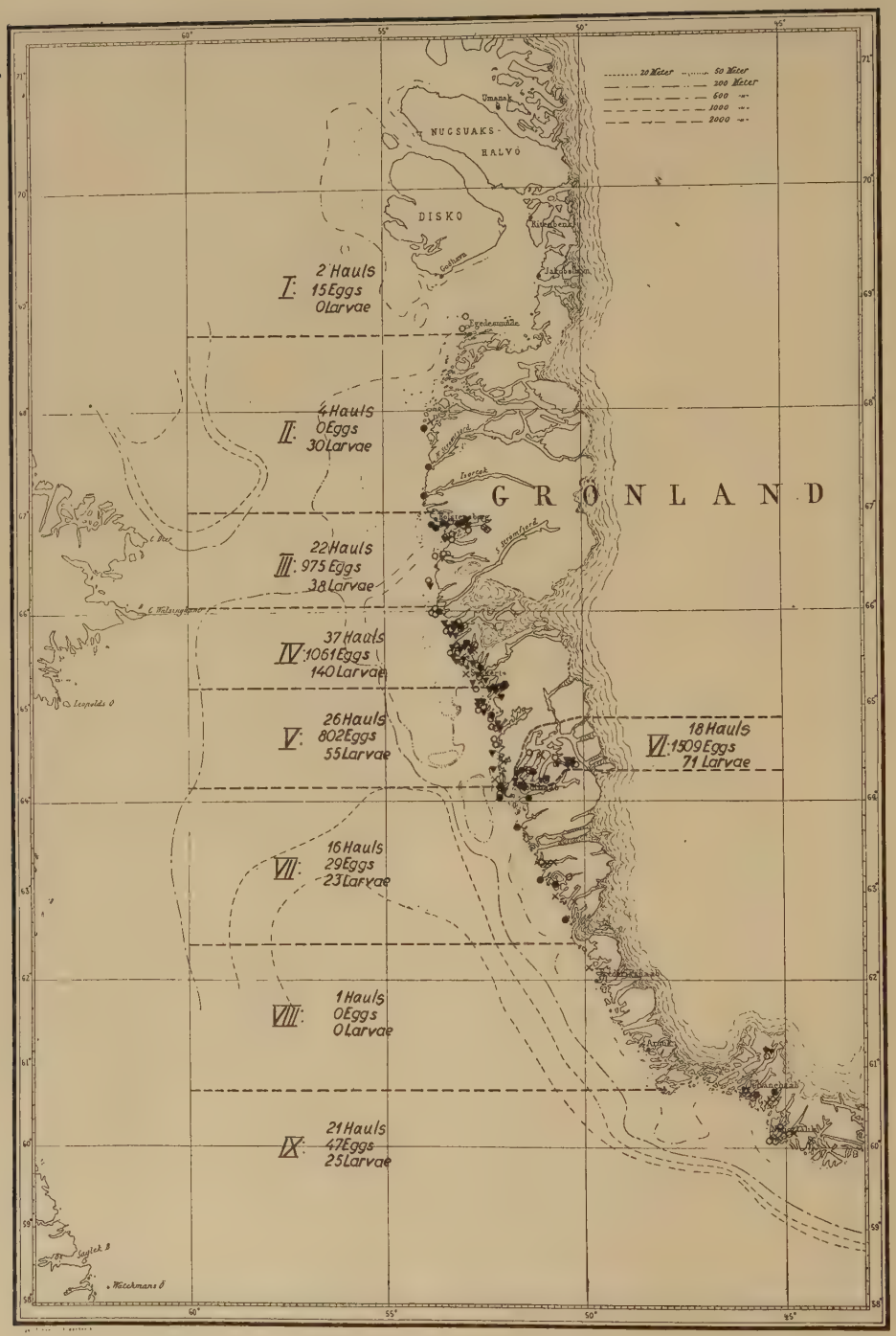
20 Meter
50 Meter
200 Meter
500
1000
2000
NUGSUAKS-
HALVØ
DISKO
GRØNLAND
I: 2 Hauls 15 Eggs 0 Larvae
II: 4 Hauls 0 Eggs 30 Larvae
III: 22 Hauls 975 Eggs 38 Larvae
IV: 37 Hauls 1061 Eggs 140 Larvae
V: 26 Hauls 802 Eggs 55 Larvae
VI: 18 Hauls 1509 Eggs 71 Larvae
VII: 16 Hauls 29 Eggs 23 Larvae
VIII: 1 Hauls 0 Eggs 0 Larvae
IX: 21 Hauls 47 Eggs 25 Larvae

Fig. 8. Number of Cod Eggs and Fry as above, at West Greenland in June.

NUGSUAKS
EALVO
DISKO
GRÖNLAND
I: 31 Hauls 0 Eggs 1 Larvae
II: 12 Hauls 0 Eggs 2 Larvae
III: 7 Hauls 0 Eggs 36 Larvae
IV:
V: 6 Hauls 5 Eggs 37 Larvae
VI: 18 Hauls 23 Eggs 79 Larvae
VII: 17 Hauls 2 Eggs 59 Larva
VIII: 14 Hauls 0 Eggs 1 Larvae
IX: 7 Hauls 0 Eggs 0 Larvae

Fig. 9. Number of Cod Eggs and Fry as above, at West Greenland in July.

Zone V to Kangek (64°10′ N. L.).
Zone VI the area of Godthaab Fjord.
Zone VII from 64°10′ N. L. to the glacier (Isblink) of Frederikshaab (62°30′ N.L.).
Zone VIII extends to Nunarssuit (60°40′ N.L.).
Zone IX embraces southernmost Greenland including Lindenow Fjord (60°30′ N.L.).

The stations for May, June and July are indicated on the charts Figs. 7, 8 and 9. Those for August and September are not included, as very few hauls were made in those months. The charts likewise indicate for each zone the number of hauls with the 1-m. ringnet, as also the catch of eggs and fry calculated for 10 hauls. The open circles on the charts indicate the catch of cod eggs, the dark spots the catch of cod larvae, the triangles the catch of both eggs and larvae, and the crosses no catch.

A shortcoming of the material is, that the number of hauls in the different months is not evenly distributed over the whole area. In May—June the hauls were mainly taken in the middle parts, whilst those in July, August and September were for a great part taken in the northern and southern zones. The reason for this was, that working conditions in early summer are best in the intermediate districts, where the winter ice or "Storis" lay no hindrances in the way of sailing, as can be the case in the northern and southern parts of the coastal area.

Considering first the average catch per 10 hauls in each month for the entire area we find, that large numbers of cod eggs were taken in May, over seven thousand per 10 hauls, whilst the fry are present in small numbers, ca. 12 per 10 hauls. In June the number of eggs per 10 hauls has greatly decreased, down to ca. 750, but the number of fry has advanced to over five times as many as in May. In July the number of eggs is inconsiderable and the number of fry has declined to ca. 26 per 10 hauls. In August and September no more eggs are taken in the hauls and the number of fry has greatly decreased in these months. The great decrease in the number of fry from June to July may be ascribed mainly to the scattering of the young by the currents. In addition, the hauls in these months lie mostly in the zones where very few cod fry occur. The reason for the very great decrease from August to September is, that a large part of the young have reached such a size that they have gone over to a bottom life; moreover, young of this size are somewhat difficult to catch in the ringnet, as they can avoid the gear.

Evidently a spawning takes place in May. It begins apparently, at least in certain mild years, already towards the end of March. The spawning extends into June. Hatching of the fry occurs in June and is completed well into July. In a few years, as in 1927, cod fry may be found already in the beginning of May. The numbers of fry are very different in the different zones.

It is evident from the charts, that the cod eggs are taken almost exclusively in the zones III, IV, V and VI—thus between ca. 64° N.L. and 67° N.L.; most of the eggs by far were taken in zone VI, that is the Godthaab Fjord. Then comes zone V, the area just to the north of this, including the waters at Napassok and the Angmasivik Fjord, where spawning is known to take place.

The cod fry seem to have a somewhat larger distribution, some being found in zone II and especially in zone VII in July, where the number of eggs had been very small. Just as with the eggs, however, it is mainly in the zones III and VI that we have considerable catches of the fry.

Considering the distribution of the eggs in May and June we at once notice, how they are unevenly distributed in May, most of the eggs being taken in the zones V and VI, contrasting with the more even distribution in June, when the eggs, greatly decreasing in numbers, are somewhat evenly distributed over the zones III, IV, V and VI. The height of spawning has come to an end in this month, and the eggs have been scattered by the current.

In May the fry are mainly taken in the zones IV and V, only a few in the zones III and VI; none occur in the other zones. In June the fry are distributed over all the zones except I and VIII (in the last however only one haul was made); zone IV shows a specially large number. Conditions are presumably the same in July when, unfortunately, no hauls were made in zone IV. In August many fry were taken in zones IV and V but none in zones VI and VII, where however very few hauls were made. In this month a few were taken in the zones I and IX, but no hauls were made in the zones II, III and VIII.

The number of eggs and fry of cod taken in the fjords and along the coast in the months of May, June and July in the different years is indicated in the scheme below (Table 7), estimated from the catches of 10 hauls of half an hour each with the 1-m. ringnet. This summary only includes catches in the zones where the numbers have been considerable, namely III, IV, V, VI and VII.

It is clearly shown by the table that the quantities of eggs and fry are in almost all cases much greater in the fjords than on the open coast. This suggests that most of the spawning takes place in the fjords, yet it must be remembered, that the eggs and fry in the coastal waters are more quickly scattered by the currents and thus carried away from the spawning places. The strong, outgoing surface current found in many fjords assuredly carries many of the cod fry out into the Davis Strait. It is probable, therefore, that the spawning which occurs in certain fjords is of importance, not only for a possible local accumulation but also for the cod along the coast and on the banks.

We also note in the table, that the quantities of fry are very different in the different years. In May, for example, the number of eggs was specially large in the fjord area in the years 1936 and 1939, whereas the years 1939 and 1935 have shown the greatest numbers in the coastal area. In the fjords in June most eggs have been taken in 1927 and 1934, whereas

Table 7.

Year	Eggs Fjord	Eggs Coast	Fry Fjord	Fry Coast	No. of hauls Fjord	No. of hauls Coast
May						
1927	3740	1517	77	34·4	10	18
1933	4348	160	—	—	5	5
1935	2455	2541	5	—	10	16
1936	71177	1450	—	—	10	23
1937	214	170	20	—	5	2
1938	315	240	5	—	2	1
1939	13165	4540	21·1	8·9	10	10
June						
1926	235	—	52·5	46·7	4	3
1927	7150	4966	140	60	2	3
1931	20	—	40	—	2	—
1933	2007·5	—	5	2	4	5
1934	3430	180	—	30·6	3	17
1935	190	347	36	41·8	5	17
1936	334·3	90·8	12·9	394·6	7	13
1937	20	1134·7	8·3	8	6	15
1938	2360	263·7	100	67·1	4	7
1939	2142	270	245	20	4	1
July						
1926	8·8	—	72·5	—	8	—
1927	27·5	—	17·5	—	4	—
1931	—	—	23·5	—	4	—
1933	—	—	5	—	2	—
1934	10	—	144	37·5	5	4
1935	—	—	30	—	2	—
1937	—	—	—	2·5	—	4
1938	46	2·5	54	137·5	5	4
1939	—	—	—	67·7	—	3

in the coastal area most were taken in 1937 and 1927. With regard to the fry of cod, the largest June catches were made in 1939 and 1927 in the fjord area, but in 1936 and 1938 in the coastal area. During the period of the investigations there have been the following good year-classes which have had great importance for the fishery at Greenland: 1926, 1931, 1932, 1934 and 1936. The 1926 quantity of fry does not seem to excel that of the other years, though we know that the 1926 year-class was one of the very best in the Greenland fishery. For 1931 the hauls have been too few to permit of a determination of the quantity of fry, and in 1932 almost all the hauls were made in zones not included in the scheme. In 1934 many eggs were taken in the fjords in June, but not specially many in the coastal waters; nor have the fry been specially numerous in any of the areas.

In 1936 very large quantities of eggs were taken in the fjords in May; at the coast also the eggs have been numerous in this month. In June of the same year very large numbers of fry have been taken in the coastal area. As will be mentioned in a later section the year-class 1936 was a very rich class in the stock of Greenland cod. As noted earlier, the available material is too small and too heterogeneous to permit of further conclusions regarding a possible correlation between quantity of fry and good or bad year-classes.

3. Off-shore Banks.

For the off-shore banks our material comes almost exclusively from the cruise of the "Dana" in 1925. In his report on the expedition Ad. Jensen (1926) gives a survey of the distribution of the cod fry in the Davis Strait. The "Godthaab" made some hauls over the banks in 1928, but its principal field of work lay much farther north and the number of hauls taken in the area where cod fry might be expected was but small. It appears from Ad. Jensen's report, that only very small numbers of eggs were taken at the various stations. Apart from stat. 2 both eggs and fry were found from the Fiskenæs Bank at 63°10′ N. L. to the Store Hellefiske Banks off Holsteinsborg ca. 66°50′. The supply of cod eggs and fry suddenly ends at this northern boundary. The same was the case in 1928. In the west the cod fry extended some distance beyond the banks. On 8.—9. June the egg field over Fylla Bank at 63°56′ N. L. was found to extend some distance to the west of this bank, eggs being taken at 53°14′ W. L. At 64°45′ N. L. on 20. June cod eggs were found from 53°13′ to 54°00′ W. L., that is from the southern part of the land side of Lille Hellefiske Bank out to the west side of this. West of the bank three hauls were made with the net, but no eggs taken. Hauls over the southern part of the Store Hellefiske Banks at 66°37′ N. L. to 66°45′ N. L. showed that cod eggs were present from 53°45′ to 56°52′ W. L., that is, from the land side to west of the bank. The last haul was made close to the edge of the west ice. The number of eggs in each haul was not large. Apart from three stations on Fiskenæs Bank, where 48, 162 and 80 eggs were taken in two hauls of one hour and one of half an hour, and on Fylla Bank, where 45 eggs were taken in half an hour, not more than 20 eggs were taken in any of the hauls.

In comparing the catches of the "Dana" with the coastal catches in the other years, 1928 excepted, we have to remember that the 2-m. net was used by the "Dana", as well as by the "Godthaab", where the 1-m. net was used in the other cases. We may reckon that the 2-m. ring-net filters about 4 times the quantity of water compared with the 1-m. net. Hence the numbers of fry taken during the "Dana" investigations have been on the whole extremely small.

In 1928 pelagic hauls with the 2-m. ring-net were made by the "Godthaab" in the Davis Strait, from the end of May to the middle of July. Cod fry were only taken in 7 hauls, excluding one haul off Hamilton Inlet at Labrador. The fry were only found in the hauls over the banks and in the one haul made near land at Ravns Storø. Cod eggs were taken at a station in shallow water somewhat off Cape Farewell, over the Dana and Fylla Banks. Cod fry were obtained at Ravns Storø and on the Store Hellefiske Bank off Holsteinsborg. At the stations outside the banks, over the deep parts of the Davis Strait, no cod fry were taken. The number of both eggs and fry was very small. Most eggs were obtained on 29. May at the

station off Cape Farewell, 59°30′ N., 45°23′ W., namely, 5, 19 and 20 in three hauls at different depths. Most postlarvae were taken on 2. July at station 34, 66°54′ N., 54°27′ W. off Holsteinsborg, namely 4 specimens. As mentioned above the main object of the expedition was the investigation of the northernmost parts of Baffins Bay and time did not permit of a more thorough investigation of the southern part of Davis Strait.

In 1926 a few hauls were made over the banks by "Islands Falk". In one haul with the $1^1/_2$-m. ring-net 6 eggs and 2 larvae were taken on 12. June at 64°00′ N., 52°36′ W. On 27. July and 28. July of the same year three hauls were made over the east edge, middle and western edge of the Fylla Bank without any result. One haul over the Store Hellefiske Bank on 16. August of the same year also yielded no result. On 11. June, 1927 38 eggs and 1 larva were taken on the Fylla Bank. In the other years only a small motor boat was available for the investigations and it was not possible to extend these beyond the coast and fjord area.

In 1931 a haul with the 1-m. ring-net was made on 15. July at 66°48′ N., 54°10′ W., Store Hellefiske Bank, but no cod fry were obtained. In 1934 on 24. May 11 cod eggs were taken in one haul over the Store Hellefiske Bank.

By comparison with the coastal and fjord area the quantity of fry over the banks is quite inconsiderable. Yet it should be noted, that the year when most hauls were made on the banks, namely 1925, was a very cold year with low temperatures, which may have had great influence on the spawning of the cod and the occurrence of the fry. Further investigations into the spawning of the cod in the Davis Strait are highly desirable. Of special importance will be an investigation of the distribution of the cod fry in the spring months of April and May. Later in the summer the cod fry will be carried by the currents away from the actual spawning places.

By comparison with the number of eggs taken in other waters during the spawning period, e. g., at Norway (Hjort 1914), the numbers in the Greenland waters are quite inconsiderable, even at Kapisigdlit in the Godthaab Fjord, where the largest quantities were obtained at Greenland. Very large spawning places, to which the cod from widespread areas collect together in the spring, are unknown as yet in Greenland. At Kapisigdlit, for example, only a very few specimens of marked cod from other localities have been obtained. The cod which spawn in this fjord come for the most part from the fjord itself and the nearby coasts, as well as from the adjacent Fylla Bank (see Fig. 21, p. 54).

B. Investigations on the Spawning of the Cod in Ikertok Fjord and Godthaab Fjord.

The investigations on the distribution of the cod fry proved that fairly large numbers occurred in some of the fjords of West Greenland. A special study has therefore been made of the spawning conditions in two of the fjord systems there, namely, the Ikertok and the Godthaab Fjords. The results may now be considered.

1. Ikertok Fjord.

The first investigations in Ikertok Fjord, which lies to the south of Holsteinsborg colony, were made in May 24.—27., **1927**. The time available for the investigations was very short, and only hauls with the ring-net were made to throw light on the distribution of the cod fry; 80 cod also were marked. These had been taken in nets by the Greenlanders at Oriok, the innermost part of the southern branch of the fjord. Only four of these cod were mature with running milt, thus males 66, 78 and 87 cm. in length. No females with running spawn were found, thus indicating that the spawning was almost over by this time.

In **1934** the investigations in Ikertok were made at two different periods, namely, from 1. to 15. May and from 28. May to 6. June.

In the first period winter ice still lay on the fjord and part of the way into the spawning places had to be covered by dog-sledge. The Greenlanders fished through holes in the ice partly off the stream at Sarfanguak, partly in Avatdleq off the settlement Sarkadlit in the inner part of the fjord. The depth fished in was between 100 and 150 m. The cod were not abundant and only small catches were made daily; none were salted, but the fish not used for home consumption were stored in frozen condition in the fish-house at Sarfanguak. Later they were sent on to Holsteinsborg when the ice broke up and motor boat traffic could be renewed.

Altogether 439 cod were examined; the total length was measured and otoliths taken for age determinations. Of the total 341 were examined just after they were taken from the water; the fish were very fat. The rest were frozen fish which had been for some time in the fish-house. These were in some cases so stiff, that they could not be cut open to determine the sex and in all cases it was impossible to determine the maturity of the organs in the frozen fish.

Fig. 10 A indicates the distribution of the age-groups

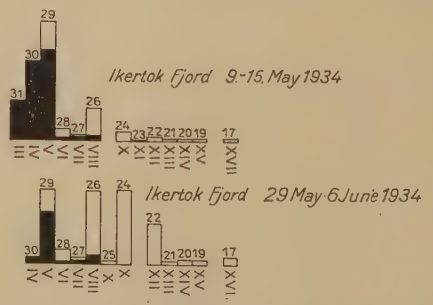

Fig. 10 A. Age Determinations of Cod on the Spawning Grounds in Ikertok Fjord. The black portions of the columns indicate the percentage of immature cod.

Table 8. Ikertok Fjord. 1.–15. May 1934.

Year-Class	Age-Group	Degree of Maturity I ♂♂	I ♀♀	II ♂♂	II ♀♀	III ♂♂	III ♀♀	IV ♂♂	IV ♀♀
1931.....	III	32	25						
1930.....	IV	44	44	—	—	—	—	—	—
1929.....	V	35	52	2	4	10	10	2	1
1928.....	VI	—	3	—	—	3	2	2	—
1927.....	VII		4		1		1	1	
1926.....	VIII	3	2	—	3	10	10	6	8
1925.....	IX	—	—	—	—	—	—	—	—
1924.....	X	—	2	—	—	—	2	2	4
1923.....	XI	—	—	—	—	—	—	—	2
1922.....	XII							2	1
1921.....	XIII	—	—	—	—	—	—	—	—
1920.....	XIV	—	—	—	—	—	—	—	1
1919.....	XV	—	—	—	—	—	—	—	2
1918.....	XVI	—	—	—	—	—	—	—	—
1917.....	XVII	—	—	—	—	—	—	—	2
	Total ...	114	132	2	8	23	25	15	21
Grand Total ...		246		10		48		36	

Table 9. Ikertok Fjord. 29. May–6. June 1934.

Year-Class	Age-Group	Degree of Maturity I ♂♂	I ♀♀	II ♂♂	II ♀♀	III ♂♂	III ♀♀	IV ♂♂	IV ♀♀
1930.....	IV	3	3	—	—		—		—
1929.....	V	9	37	—	—	10	1	6	8
1928.....	VI	2	—	—	—	3	3	4	2
1927.....	VII	1	2	—	—	1	—	2	1
1926.....	VIII	—	4	—	—	2	1	28	25
1925.....	IX	—	1	—	—	—	—	—	2
1924.....	X	—	—	—	—	—	—	36	26
1923.....	XI								—
1922.....	XII	—	—	—	—	3	2	18	14
1921.....	XIII	1	—	—	—	—	—	1	1
1920.....	XIV	—	—	—	—	—	—	2	3
1919.....	XV	—	—	—	—	—	—	2	2
1918.....	XVI	—	—	—	—	—	—	—	—
1917.....	XVII	—	—	—	—	—	—	2	5
	Total ...	16	47	—	—	19	7	101	89
Grand Total ...		63				26		190	

in the catch; the black portions of the columns show the percentage of the immature in the single age-groups. We see, that the age-groups III (1931 year-class), IV (1930) and V (1929), contributed most of the catch, about 80 %. Among the older age-groups VIII (1926), X (1924) and XII (1922) were specially prominent. Immature fish were however in the majority.

Details concerning the maturity of the cod are given in Table 8; the degree of maturity is given here according to SIVERTSEN's scale (1937).

The Roman numbers in the columns indicate: I — immature, II — ripening, III — ripe, IV — spent.

As mentioned above, the great majority of the cod examined were immature. Among the mature only a few, only 10 cod, were in stage II, whilst stages III and IV were represented by respectively 48 and 36 specimens, indicating that spawning was in full swing.

Of the younger age-groups which took part in the spawning, the V to VIII groups, most were in stage III, thus ripe, spawning individuals. The older groups, X—XVII, were represented almost wholly by spent fish, stage IV; the older fish have thus spawned earlier than the younger. As the material of spawning cod is so small we can hardly conclude that this condition holds good generally.

None of the individuals belonging to the youngest age-groups, III and IV, were mature. Of the V-group about 30 % of the males and about 22 % of the females were mature. All the males in the X and older groups and the females in the XI and older groups were mature. As mentioned, the old age-groups were very sparingly represented; thus, the IX-group was quite absent.

The smallest mature cod was a female; it measured only 53 cm. and belonged to the V-group.

The investigations in Ikertok and in Amerdlok at Sarfanguak were renewed on 29. May to 6. June. The ice had broken up by then and melted or been driven out, so that the whole fjord was free of ice. Everywhere in the fjord one could observe the cod pursuing the capelan (*Mallotus*) on the surface. The cod did not take the bait on the long-lines but were easily caught by a bright jig in shallow water. The investigation showed clearly, that the stock had changed since the first half of the month. Certainly some of the smaller, fat cod were taken as before, but the majority were large and thin. The condition of the organs showed that they had all spawned. As shown in the diagram, representing 299 specimens, the age-groups V, VIII and X (the year-classes 1929, 1926 and 1924) were the largest with almost the same numbers. The age-group XII (1922) was a little more than half as numerous. But few immature cod were present.

The results of the maturity analysis of part of the catch are given in Table 9. It will be seen, that stage II is not represented, and very few of stage III, whilst by far the greater number were in stage IV, thus spent cod. It may be noted, that the results in Table 9 cannot be compared directly with those in Table 8. Table 9 gives the conditions for a mixed stock, that is to say, the local stock of the fjord, represented in Table 8, plus the immigrant, spent cod. That very few ripe cod were taken shows that spawning was nearly finished.

The many large cod taken in the fjord have migrated in from the coast and the banks, presumably from the Store Hellefiske Bank. It is a migration that takes place every year, giving occasion for an extensive fishery in which nets (gill-nets) are most frequently used. For part of the time at any rate the cod are not inclined to bite at hooks when they can feed on the rich abundance of capelan, which at this time of year come near the shore to spawn. The marking experiments on the Store Hellefiske Bank have only yielded two recoveries in the fjord area.

On the other hand, according to the Greenlanders

hooks of a special type have been found in the cod. The author has seen two of these and confirmed that they are of the kind used by the French fishermen. These fishermen work chiefly on the Store Hellefiske Bank. It is probable, therefore, that the cod mainly come from there. The marking experiments in the fjord have yielded many recaptures from the fjord itself and also on the banks and along the coast, a few to the north, most from the south of the fjord. Two recoveries from Icelandic waters are to hand from a marking experiment in Ikertok in July 1931 (v. section on migrations of the cod, p. 51 and Fig. 18, p. 52).

2. Godthaab Fjord.

It was already found on the "Dana" cruise of 1925, that the cod spawn in the Kapisigdlit arm of the Godthaab Fjord; on 15. June of that year 2, 712 eggs and 9 fry of the cod were taken in a haul of half an

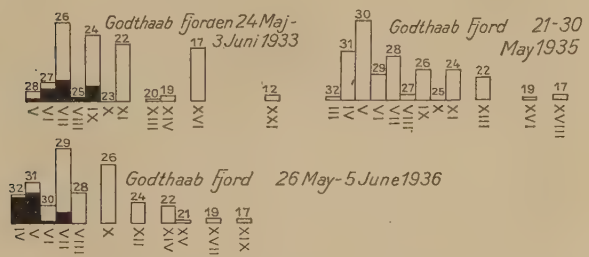

Fig. 10 B. Age Determinations of Cod on the Spawning Grounds in Godthaab Fjord. The black portions of the columns indicate the percentage of immature cod (not included 21.—30. May 1935).

hour with the 2-m. ring-net (Jensen 1926). In the period when spawning takes place the locality has been visited in the years 1933, 1935 and 1936 for the purpose of investigating the spawning conditions.

Cod are found at Kapisigdlit all through the winter and the Greenlanders fish for their home consumption through holes in the ice, just as in the Ikertok Fjord. They have known for a long time, that the cod spawn at Kapisigdlit and in the spring time they dry quantities of almost ripe cod roe on the rocks. During and after the war great quantities of dried and salt cod have been produced at Kapisigdlit in the winter months.

We may now consider in detail the investigations made in 1933, 1935 and 1936; in the three years they were made over the same period or nearly so, namely from 21. May till 6. June.

The investigations made in **1933** on the spawning of the cod in Godthaab Fjord have been described on an earlier occasion (Hansen 1934). In the period from 26. May to 3. June altogether 327 cod were examined; these were caught on long-lines at Kapisigdlit. The cod were measured, the age determined from the otoliths and the degree of maturity examined. The results of the age determinations are shown in Fig. 10 B. The black portion of the columns indicates

Table 10. Godthaab Fjord 1933.

Year-Class	Age-Group	Degree of Maturity I ♂♂	I ♀♀	II ♂♂	II ♀♀	III ♂♂	III ♀♀	IV ♂♂	IV ♀♀
1929.....	IV	1	1	—	—	—	—	—	—
1928.....	V	3	6	1	—	1	—	—	1
1927.....	VI	6	7	2	—	3	2	1	1
1926.....	VII	4	18	16	16	8	13	4	5
1925.....	VIII	—	3	—	—	—	—	—	—
1924.....	IX	4	14	12	9	10	20	1	1
1923.....	X	—	—	—	—	2	—	—	—
1922.....	XI	—	4	11	9	6	24	3	3
1921.....	XII	—	—	—	—	—	—	—	—
1920.....	XIII	—	—	—	1	—	—	—	—
1919.....	XIV	—	—	2	2	2	3	—	1
1918.....	XV	—	—	—	—	—	—	—	—
1917.....	XVI	—	—	14	16	11	11	1	—
1916.....	XVII	—	—	—	—	—	—	—	—
1915.....	XVIII	—	—	1	—	—	—	—	—
1914.....	XIX	—	—	—	1	—	—	—	—
1913.....	XX	—	—	—	—	—	—	—	—
1912.....	XXI	—	—	4	1	—	—	—	—
Total ...		18	53	63	55	43	73	10	12
Grand Total ...		71		118		116		22	

the percentage of immature individuals. The sample consisted for the most part of the age-groups VII, IX, XI and XVI (the year-classes 1926, 1924, 1922 and 1917). These are the same groups which have been dominant also in the material from other Greenland stations. It will be seen, that the mature cod greatly exceed the immature. Mature cod occur in almost the same numbers in each of the four dominant groups.

The maturity of the cod is represented in Table 10. In the case of some females, especially the young, it was sometimes difficult to determine whether they were immature or spawning, as the ovaries were small and of a faint red colour. When the ovary was cut open, however, it was found to contain small quantities of ripe, loose eggs. These individuals were therefore nearly spent. This condition occurs apparently in individuals spawning for the first time. No ripe specimens have been found in the age-group IV, but it should be noted, that this age-group is only represented by 2 specimens. In the V-group there are 2 ripe males. Not until the VI-group do we have 3 ripe females, whilst 6 of the males have reached maturity. In the VII-group there are more mature than immature. In the X and all older groups all the specimens are mature, except 4 fish of the XI-group. Only 2 individuals of the X-group are present in the material, but the XI-group is fully represented.

The available material is too small to show, whether there is any difference in spawning time for the younger and older year-classes.

In **1935** investigations were carried on in the inner part of Godthaab Fjord in the period 21. to 30. May. At this time there were not very many cod at Kapisigdlit, though many were taken at Umanak and in the two fjord branches Patusok and Amitsuarsuk. They were however always on the track of the capelan and where many might be found one day, fishing on

Table 11. Godthaab Fjord 1935.

Year-Class	Age-Group	Degree of Maturity I ♂♂	I ♀♀	III ♂♂	III ♀♀	IV ♂♂	IV ♀♀
1931.....	IV	9	6	—			
1930.....	V	6	13	—	—	-	
1929.....	VI	—	—	—	—	1	—
1928.....	VII	2	1	—	—	3	
1927.....	VIII	—	2	—	—	1	1
1926.....	IX	—	1	1	2	12	11
1925	X	—	—	—	—	3	-
1924	XI	—	1	1	2	8	22
1923.....	XII	—	-	—	—	-	
1922.....	XIII	1	—	—	4	8	9
1921.....	XIV	—	—	—	—	—	-
1920.....	XV	—	—	—	—	—	—
1919.....	XVI	—	—	—	—	—	3
1918.....	XVII	—	—	—	—	—	—
1917.....	XVIII	—	—	1	—	3	4
	Total ...	18	24	3	8	39	50
Grand Total ...		42		11		89	

Table 12. Godthaab Fjord 1936.

Year-Class	Age-Group	Degree of Maturity I ♂♂	I ♀♀	III ♂♂	III ♀♀	IV ♂♂	IV ♀♀
1932.....	IV	13	15	1	—	—	—
1931.....	V	20	10	2	5	5	—
1930.....	VI	2	—	7	3	6	1
1929.....	VII	5	6	25	24	12	1
1928.....	VIII	1	—	6	18	4	3
1927.....	IX	—	—	—	—	—	—
1926	X	—	—	13	40	4	5
1925.....	XI	—	—	—	—	—	—
1924.....	XII	—	—	7	7	3	1
1923	XIII	—	—	—	—	-	
1922.....	XIV	—	—	2	9	2	
1921.....	XV	—	—	—	—	1	1
1920.....	XVI	—	—	—	—	—	
1919.....	XVII	—	—	—	1	3	—
1918.....	XVIII	—	—	—	—	-	
1917.....	XIX	—	—	—	—	2	1
	Total ...	41	31	63	107	42	13
Grand Total ...		72		170		55	

the next would be quite in vain. Altogether 256 cod were caught, and of these 106 were marked. Only the cod with strongly running milt or roe were marked and of these 93 were males and only 13 females. The unripe were used for an examination of the condition of the sex organs and for the age determinations. The results of the age determinations are shown in Fig. 10. As so large a proportion were spawning and were thus marked, these are not included in the age determinations; consequently, the graph does not give quite a complete picture of the composition by age of the stock in the fjord, at least not so complete as in the other years. Table 11 is incomplete for the same reason, since the many marked cod, all belonging to stage III, could not be included in the various age-groups.

It will be seen from Fig. 10 B that more of the young age-groups are contained in the sample than in 1933; thus many individuals of the groups IV and V, from the years 1931 and 1930. The VII-group from 1928 was the third largest. The IX, XI and XIII-groups, from 1926, 1924 and 1922, were the only ones of the older groups to be considerably represented. There were still a few of the XVIII-group from 1917. Table 11 shows, that many more females were spent than spawning, thus indicating that the spawning was nearly at an end. The spawning has apparently taken place at Kapisigdlit; after that the cod have scattered over the rest of the fjord. The spawning must have been earlier than in 1933. Mature males first occur among the VI and VII-groups; only mature were found in the older age-groups with exception of the XIII-group which contained a single immature male. With regard to the females we find the first mature in the VIII-group, one individual. Many more were mature in the IX-group than immature, in the proportion of 13 to 1. In the older age-groups only one immature individual was found; it belonged to the XI-group.

In **1936** when the investigations were undertaken, from 26. May to 5. June, spawning was in full swing at Kapisigdlit. In all 297 cod were examined. The age determinations of the sample are given in Fig. 10 B. The black part of the columns indicates the percentage of immature individuals. We did not find here the condition mentioned under the 1933 investigations, namely, that many females had small pink ovaries, like the immature females, which nevertheless contained loose eggs ready to be set free.

The results of the investigation are given in Table 12. Among the year-classes represented that of 1929 is the largest; the 1926 class comes second. Considering only the spawning and spent cod the totals are equal for these two year-classes.

The old year-classes 1924, 1922 and 1917, of some importance in 1933 and 1935, have greatly decreased. The years 1932 and 1931 are well-represented and the latter especially, considering the age, has many individuals which are either spawning or spent.

A single male of the IV-group is spawning and this is the youngest cod found spawning in Godthaab Fjord. In the V-group about a quarter of the males and a third of the females are spawning or spent. The IX-group is not represented in the material. All the cod older than 10 years are mature. Noteworthy is the comparatively large number of spawning females in the V-group (from 1931). In 1933 and 1935 only one female (1933) belonging to this age-group had been mature. This indicates that individuals of the 1931 class had reached maturity at an earlier age than usual.

There are more spawning than spent of both males and females. This is evident especially in the case of the females, only 13 being spent whilst 107 are spawning. This shows, that spawning was at its height when the investigations were being made.

3. The Temperature at which the Spawning of the Cod takes Place in Ikertok and Godthaab Fjords.

In the survey of the biology of the cod given earlier (HANSEN and JENSEN 1930 and 1931) reference was made to the temperature of the water at the spawning time. "In the spawning time the temperature of the water near the bottom is everywhere low; varying at a depth of 50 m. between + 1·73° and —0·27° at different places. On the other hand, near the surface where the eggs float and hatching takes place the temperature is considerably higher; 1·45°—2·75° at 10 m. and 2·53°—5·6° at the very surface, a condition that must greatly aid the development of the embryo." When this was written, no observations had been made on the actual spawning grounds of the cod and it was not known at what depths the cod spawned at Greenland. During the present investigations in the Ikertok and Godthaab fjords observations of temperature were made over the depths where the cod were spawning and also in the water-layers concerned.

It should be noted, however, that we have to deal with local populations in these fjords, which may well be able to spawn under conditions different from those under which the cod spawn in Davis Strait and at the coast.

When the spawning place in Ikertok was visited on the 1.—15. May 1934 the cod were spawning at a depth between 100 and 200 m. As the journey had to be made by dog-sledge over the fjord ice, it was not possible unfortunately to take apparatus for hydrographical observations and these had to be omitted. In the second period from 29. May to 6. June, when the locality was again visited, the ice had gone and the journey could be made with a motor boat.

Table 13, I—VIII, gives the temperatures for various localities at different depths and dates. I, in Ikertok off the place where the fjord branches; II, at the mouth of Amerdlok.

The spawning cod were taken at a depth of between 100 and 200 m., and the temperature there was probably somewhat above 1°, taking into account the circumstance that the observations were made almost a month later, so that the temperatures may have risen a little in the interval.

At Kapisigdlit, Godthaab Fjord (III), the cod were at a depth between 25 and 50 m., and this means, that the spawning temperature has been between 1 and 4 degrees. The high temperatures from 25 m. up to the surface, 3·72° to 4·8° C, the layer in which cod eggs were found, may be considered specially favourable for the development.

In half an hour's haul with the ring-net of 1 m. on 25. May 2,000 cod eggs were obtained; 800 were taken in one haul on 3. June.

Outside the Pisigsarfik branch of the fjord (IV), where Kapisigdlit forms the inner part, in the fjord basin off the mouth of the Kangersunek branch, much lower temperatures were found in the upper layers.

At Kapisigdlit (V), the temperatures were in 1935 distinctly higher, except at 25 m., than in 1933.

Only small quantities of the cod were found here, but it was abundant in the fjord basin outside Pisigsarfik and large shoals were present in the Patusok branch of the fjord and at Amitsuarsuk. The spawning was almost over and the cod were pursuing the capelan.

The temperature was considerably lower in the fjord basin (VI) in all layers than at Kapisigdlit. The cod were taken in the upper layers from 50 m. to the surface, thus in temperatures varying between 0·5° and ca. 3°. At Kapisigdlit the number of eggs taken was not very large; in half an hour's haul with the 1-m. ring-net on 21. May 198 eggs were taken, whereas on 20. May off Pisigsarfik 1068 were taken in the fjord basin in one haul. The majority of the cod eggs thus seem to have been carried out from Kapisigdlit.

In 1936 the spawning was at its height when observations were taken from 26. May to 6. June.

The temperature conditions at Kapisigdlit (VII) were somewhat similar to those found on 23. May 1935. The cod were thick at a depth of 25—50 m., thus at over 2° to 3·6° C. The eggs occurred near the surface and were far more numerous than in the previous year or 1933; the temperature was round 5°—6°.

In the fjord basin (VIII) the temperatures this year were considerably higher than in the other years when investigations were made. As noted above, the cod eggs were found in much greater numbers in hauls with the ring-net on 26. May at Kapisigdlit than in any other year. When hauls with the ring-net

Table 13. Temperatures at various Depths, Localities and Dates.

	I	II	III	IV	V	VI	VII	VIII
	5.6.1934	24.5.1934	25.5.1933	25.5.1933	23.5.1935	20.5.1935	26.5.1936	24.5.1936
Depth m.	Ikertok, where the fjord branches	At the mouth of Amerdlok	Kapisigdlit, Godthaab Fjord	Outside the Pisigsarfik branch of Godthaab Fjord	Kapisigdlit	Fjord Basin outside Pisigsarfik	Kapisigdlit	Fjord Basin
0	2·7	1·65	4.8	3·9	8·35	3·7	6·3	2·8
10	2·5	1·23	4·84	1·05	6·70	0·55	5·19	2·16
25	—0·43	—0·27	3·72	1·02	2·95	0·83	3·63	2·00
50	—0·80	—0·28	0·99	1·40	2·00	1·07	2·06	1·92
100	1·87	0·50	1·48	0·86	2·03	0·57	2·12	1·92
200	1·85	1·35	—	0·67	—	0·44	—	1·38
300	1·62	1·43	—	—	—	0·89	—	—

were again made on 6. June, the eggs were in much smaller numbers, e. g., 16 in one haul and 202 in a second. The eggs thus seem to have been carried out of the fjord branch in the interval.

The temperature conditions affecting the spawning and hatching of the eggs of the cod in Godthaab Fjord may be summed up as follows.

In Kapisigdlit, the innermost part of the small branch of the fjord Pisigsarfik, fairly high temperatures are found in the water in May, higher than in the outer part of Godthaab Fjord, where the water is mixed with the cold water from the ice-fjord Kangersunek. The cod spawn at Kapisigdlit in May and some years a little into June at a depth between 50—100 m. and temperatures between 1° and a little over 2°. The eggs, which float on the surface in large numbers at the time when the principal spawning is carried on, drift out of the fjord branch and are scattered over the other part of the fjord; some of the fry are probably carried right out of the fjord area.

C. Age of Cod at First-Maturity in the Coastal Area.

In the section on the spawning conditions in Ikertok and Godthaab Fjords reference was made to the age when the cod first become mature in these fjords. The observations were based on spawning cod and in both cases it was a matter of local populations. Similar observations have not been made on the cod of the coast and on the banks, as these were not found spawning. In these cod we have a means of studying the age at first-maturity in the spawning rings of the otoliths; these rings have been demonstrated for the Arctic-Norwegian cod by Rollefsen (1933). As in these, so in the Greenland cod it is possible to detect a more or less distinct zone-division in the otoliths. Some of the outermost rings in the otoliths of the older cod are closer together, narrower and clearer than the inner rings and are believed to be formed in the years when the cod has been spawning. The innermost of these outer rings is thus the ring which has been formed in the first year the cod has spawned. In the age determinations of the otoliths the position has been in many cases noted of this first spawning zone and in this way the age at first-maturity has been determined.

We shall only consider here the age at first-maturity in some of the richest year-classes which have occurred in the Greenland fishery, namely, 1917, 1922, 1924, 1932, 1934 and 1936. The material may be divided into two parts, one from the northern part of Greenland and the other from the Julianehaab district.

1. Northern Area.

For the year-classes 1917 and 1922 we have the material from Holsteinsborg collected in 1931 and from Kangamiut and Sukkertoppen collected in 1934, thus cod of respectively the XIV- and XVII-groups, as also of the IX- and XII-groups. The material of the 1924 year-class was collected in Kangamiut and Sukkertoppen in 1937, thus cod of the XIII age-group. The material used in the investigation of the year-classes 1934 and 1936 comes from 14 and 19 stations in North Greenland in 1946, thus cod of the XII and X age-groups.

Fig. 11 shows the distribution according to age when the first spawning took place in cod belonging

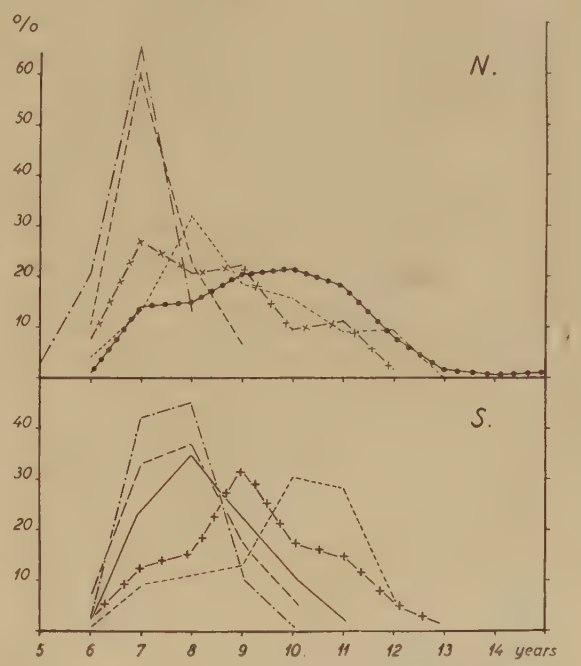

Fig. 11. Diagrams to show the Age at First-Maturity in different year-classes of Cod. *N.* for the northern districts. *S.* for the southern.

1917 ·—·—·— 1932 ————
1922 – – – – – – 1934 — — — —
1924 —×—×— × 1936 . . . .

to the year-classes 1917, 1922, 1926, 1934 and 1936. It will be seen, that the age at first-maturity for the year-class 1917 is spread over six to fifteen years. A very small number (1·2 %) has been able to spawn for the first time at six years. The percentage rises each year till the tenth, when the percentage is highest, and then falls evenly. A single individual has spawned for the first time at an age of 15 years. Of the cod of the 1917 year-class 60 % have reached maturity at the ages nine to eleven years. The average age at first-maturity for this year-class is 9·9 years.

The year-class 1922 differs somewhat from the 1917 class. The age at first-maturity varies from six to thirteen years; at eight years most have reached maturity (30·8 %); 64·7 % have become mature between eight and ten years. The average age at first-maturity is 8·6 years.

For the year-class 1924 the average age at first-maturity is 8·4 years.

For the year-classes 1934 and 1936 the ages are quite different from those of the 1917 and 1922 year-classes. Most of the individuals by far, respectively 60·6 % and 64·6 %, have reached maturity at an age of seven years, and no individuals of these year-classes have become mature later than nine years. Of the year-class 1936 five individuals (1·2 %) were already mature in their fifth year. The average age at first-maturity was 7·8 for the year-class 1934 and 6·9 for the 1936 class.

It is evident, therefore, that maturity has been reached by these two year-classes at a much earlier age than has been the case in the older classes.

2. Southern Area.

The samples examined in this area came from the year-classes 1922, 1924, 1932, 1934 and 1936. The material of the year-class 1922, consisting of 147 otoliths, comes from stations in the Julianehaab district and were collected in 1934 (92 specimens) and 1935 (52 specimens). These cod therefore belonged to the XII and XIII age-groups. The material of the year-class 1932 was collected in 1946; it consists of 46 otoliths of cod belonging to the XIV age-group. The material of the year-classes 1934 and 1936 was collected in 1947, belonging therefore to the XIII and XI age-groups respectively; the number of specimens in the samples was 88 and 39. The material is thus not large, due to the fact that the old year-classes had to be taken for the sake of comparison, and old cod as a rule are only present in the Julianehaab district in small numbers.

Fig. 11 shows very clearly, that a change has also taken place in the southern area with regard to the age of the cod at first-maturity. In the year-class 1922 most of the first-time spawners, 57·1 %, were 10 and 11 years old and their average age was 9·3 years. The year-classes 1932, 1934 and 1936 had most first-time spawners at the age of 7 and 8 years. Only a few have spawned for the first time at the age of 10 and 11. For these three year-classes the average age at first-maturity has been 8·1, 7·8 and 7·6.

Thus in both the northern and the southern area there has been a change in the age at first-maturity from higher to lower years. This change has possibly been connected with changes in the hydrographical conditions. At higher temperatures in the sea maturity may be hastened and attained earlier. According to Dunbar (1946) the warm period reached its peak in the middle of the thirties and it is natural, therefore, that the younger year-classes, influenced by the higher temperatures, have reached maturity at an early age, whereas the older classes of 1922 and especially of 1917, developing before the warm period had fully arrived, had become mature at a later age.

In Newfoundland Harold Thompson has found, that the majority of the cod spawn for the first time at an age between 6 and 9 years and at a length between 60 and 80 cm. Practically all cod of 9 years of age or over are adults. This is to some extent in agreement with the results obtained for the cod of West Greenland.

For the cod at Iceland Sæmundsson (1927 p. 25) states, that the males reach maturity at an age of 4 to 7 years and at lengths between 60 and 70 cm.; for the females the age and lengths are respectively 5 to 9 years and 70—80 cm. At south and west Iceland maturity is reached at an earlier age and smaller length than on the north and east coasts.

At the south coast of Norway near Arendal Dannevig (1933) reports, that the cod reach maturity and spawn from the third to the twelfth year (mostly from the fourth to the sixth). Rollefsen (1935, 1938) has found from his studies on the otoliths of the Lofoten cod, that the age at first-maturity extends from 6 to 16 years (mainly 8, 9 and 10 years).

D. Distribution of the youngest Age-Groups of Cod at Greenland.

An earlier section has described the distribution of the eggs and fry of the cod; here we may consider the distribution of the youngest age-groups, namely I, II and III, and their connection with the places where the fry occur. It is of interest naturally to learn, where these young cod grow up and in which year they occur in abundance, since at some time, when they are large enough, they come to be of importance for the commercial fishery. The quantitative occurrence of the various year-classes of small cod will be discussed however in a later section; here we are considering only the localities where catches of the small cod have been made.

These young cod have been sought after with eel-nets in coves and bays along the coast and in the fjords. It is only places where the bottom is smooth and even, that this apparatus could be used without difficulty. Often it is impossible to work such a net owing to the large stones and rocks or thick clay at some river mouths, where the net digs itself into the clay. In some of the quiet inlets the accumulations of rotten vegetation, including large Laminaria, may be so great that it is impossible to use the net. In some localities where stones occur, fishing may well be carried on but only when the net is lifted over the stones, which means part of the catch being lost under the net. At a few localities where the bottom was very bad, good results have nevertheless been obtained when the cod were close in on the beach, by enclosing some cod in the one arm of the net.

It will be understood from all this, that the hauls with the eel-net can only approximately give any quantitative determination of the numbers of the youngest year-classes at the different localities; any comparison between these localities and between the numbers of small cod in the different years cannot be other than imperfect. Such a comparison could better be made for the tiny fry taken with the pelagic nets.

Table 14. Catches of small Cod of I–III-Groups with Eel-Net in the Period 1926–39.

Zone	May–June			July–August			September–October			Total
	No. of Hauls	No. of small Cod	No. per 10 Hauls	No. of Hauls	No. of small Cod	No. per 10 Hauls	No. of Hauls	No. of small Cod	No. per 10 Hauls	Number of Hauls
I a	—	—	—	17	3	2	—	—	—	17
I b	—	—	—	10	3201	3201	—	—	—	10
II				—	—	—	—	—	—	—
III	1	—	—	4	337	843	—	—	—	5
IV	17	1704	1000	8	2564	3205	—	—	—	25
V	—	—	—							
VI	22	2745	1247	14	479	342	—	—	—	36
VII	14	3249	2321	11	24	22	2	10	50	27
VIII	11	100	91	55	6431	1169	3	34	113	69
IX	12	20	17	124	10414	840	17	300	177	153
Total	77			243			22			342

In addition to what has been said above regarding the difficulties in the way of obtaining representative catches of small cod, it may be mentioned that the young cod of the same size keep together in shoals and are thus not easily taken in the net. It has often happened, that a number of small cod were taken in one haul, whilst several other hauls at the same place have missed them. The I- and II-groups are the most readily caught, whilst the III-group are as a rule difficult to catch with this gear, as the individuals of this group usually keep farther out from the beach than the others. In many cases small jigs have been used for the capture of individuals of the III-group. These are usually too small to be caught in the commercial fishing gear. Larger individuals of the II-group have also been caught in the same way. In 1938 a number of cod of the youngest age-groups have been taken in a trawl in Amerdlok Fjord during the prawn fishery in deep water, ca. 200—400 m.

At the end of August 1948 many I-group cod were caught with the shrimp-trawl at 380 m. depth in Christianshaab district. In June—July only very few small cod were caught with the same gear at the same localities. This suggests, that, in the autumn, the small cod seek out to greater depths.

During the period 1926—1939 342 hauls with the eel-net were made. Table 14 shows the distribution of the hauls in May—June, July—August and September—October in the various areas of the coast and fjords, from Umanak Fjord to the southern Julianehaab district. Most of the hauls were made in July—August and most were made in the Julianehaab district, next come Frederikshaab and Godthaab.

In May—June, as Table 14 indicates, the catches of small cod were almost entirely made in the Sukkertoppen district and at Godthaab (zones IV, VI and VII). In Frederikshaab and Julianehaab districts (zones VIII and IX) practically no catches were made, probably because the waters there near the beach are colder in the early summer than in Godthaab and Sukkertoppen, owing to the Polar Current and the presence of "Storis". In the Holsteinsborg district (zone III) only one haul was made and farther north the net has not been used in these months.

In July—August fishing with the eel-seine was carried on along the whole coast except in the Egedesminde district. The largest average catches per 10 hauls have been made at Sukkertoppen (zone IV—V), Disko Bay (zone I b), Frederikshaab (zone VIII), Holsteinsborg (zone III) and Julianehaab (zone IX).

The hauls in the southern districts are grouped round quite definite localities, where fishing with the eel-seine has been carried on in several of the years when investigations were made. The reason was, that these localities offered specially favourable bottom conditions; again, it has also been an advantage that quantities of herring occurred there and many hauls with the seine were made to get the herring. The localities where such conditions prevail lie in the Frederikshaab district, in Sarfat at Avigait and Inugsuk at Tylorshavn in Arsuk Fjord, and in the Julianehaab district especially at several places in the neighbourhood of the outpost Sardlok.

At these localities in addition to good catches, some hauls yielded none, due in some cases to the fact, mentioned above, that the small cod often go about in shoals; in other cases large quantities of small cod may be found in some years, but almost none in others. The latter condition, arising from the presence of good and bad year-classes in the stock, will be more closely considered in a later section. Contrasting the areas where good catches of small cod were made with the areas where the ring-net was used to get the eggs and postlarvae, we notice this peculiarity, that many small cod were taken both in the two southernmost districts and in Disko Bay—areas where practically no tiny cod fry had been fished and where, we may conclude, very little or no spawning takes place.

In Table 14, showing the catches per 10 hauls, the same division of the coast into zones has been used as for the distribution of the cod fry, but zone I has been divided into two, I a—Umanak Fjord and I b—Vajgat and Disko Bay. It will be seen that the material is scanty and unequally distributed over the different zones. This and the already noted conditions make a comparison between the different areas difficult, yet we may conclude, that the distribution of the small cod along the coast is fairly uniform

right from Disko Bay down to the Julianehaab district.

Considering first the Umanak Fjord (I a) we see, that no tiny fry of the cod were taken with the pelagic nets. With the eel-seine small cod were only taken at two places in 1936, at the one only 1 specimen, at the other 2. The first was taken at Ikerassak on July 17. 1936 far up in the fjord; it measured 31 cm. and belonged to the II-group. On July 20. in the same year 2 small cod of the I-group—71 and 75 mm. long —were taken at Umiartorfik. During the investigations made in 1948, extremely large shoals of small cod of the I—III-groups were observed in the whole Umanak Fjord, and there were also large shoals along the whole coast of West Greenland south of Umanak Fjord. The I-group was by far most numerous. In the Umanak Fjord the inhabitants had never had a similar experience. From the trading station (Prøven in the Upernavik district (ca. 72°25′ N.Lat.) some few I-group cod were received, but we have no information about any mass occurrence in this district in 1948. In Disko Bay many of the hauls with eel-seine resulted in good catches of small cod of I- and II-groups in 1935, when shoals of the I-group were present everywhere and again in 1936 when fairly good catches of the II-group were made at a couple of places. Thus, August 17, 1936, at Kekertak, ca. 70° N. L., the most northerly locality, where small cod were present in large quantities and where we caught 452 specimens, most of them belonging to the II-group (from 1934).

During the first investigations at North Greenland, "Dana" 1925, three hauls were made with the eel-seine at Godhavn. In these only large ogac were taken; not a single cod. In 1932 the Danish Marine-biological Laboratory received 19 small cod of the I-group (from 1931) from mag. scient. Porsild; these had been caught in the harbour at Godhavn. They were the first mag. Porsild had seen. In 1935 one haul yielded 1586 small cod of the I-group (1934 year-class).

It was not a chance happening, that small cod could be taken at Godhavn in 1932 and 1935; in these years many individuals of the rich year-classes 1931 and 1934 were present. It should also have been possible to catch many of the I-group in 1925, for the year-class 1924 was one of the richest at Greenland at any time.

As mentioned however, no small cod were taken at Godhavn in 1925. This may have been a chance naturally, but the more probable explanation is, that no small cod were present in the area in 1925, their distribution at that time being on the whole more restricted than later. Considering the catches of the tiny fry taken in the ring-net, we see that they were very small in this area (zone I), namely, altogether only 3 eggs and 7 larvae with the 1-m. ring-net. It might be thought that it was only in some years that no fry were taken in Disko Bay and Vajgat, but many in other years, and that since the investigations were only made in a few seasons, 1925, 1928, 1935 and 1936, these have been years of poor supplies in the area. This is very improbable, however, as 1936 was a year when many of the fry were taken in the more southerly areas at West Greenland, and the year-class 1936 became one of the very rich year-classes in the cod stock of Greenland.

It may be assumed, that the cod fry are carried up to Disko Bay and Vajgat by the north-going current from the spawning places farther south. If they are not taken in the ring-net, the reason is that by the time they come to Disko Bay, they are of such a size they can escape the net. In a later section dealing with the numerical characters of the Greenland cod it will be shown, that the average number of vertebrae in cod from Godhavn, Rode Bay and Christianshaab is certainly a little greater than the average in cod from the intermediate part of Greenland, yet not so much greater that a connection between the cod of the two areas is excluded. There is nothing therefore to oppose the belief, that the cod up from Disko come from more southerly areas. Many of the large cod examined from Disko Bay have been mature and the otoliths show, that they have spawned several times. As the investigations have shown that no spawning occurs in Disko Bay, it may be concluded that these cod migrate southward to spawn, presumably over the edge of the banks south of Holsteinsborg, and return from there towards the summer. No large cod are found in the Disko Bay region in early summer. When the capelan shoals arrive there in June for spawning on the shore, they are never seen to be pursued by cod as they always are in South Greenland waters.

At the end of June and in the beginning of July 1948, large shoals of capelan were observed at various localities on the shore in Disko Bay, but not a single big cod.

In Julianehaab and Frederikshaab districts, as mentioned earlier, several large hauls of small cod were made with the eel-seine. From the charts showing the distribution of the cod fry in the different months (Figs. 7, 8 and 9, p. 17—19) we see, that in these two districts hardly any fry were taken; this indicates that no spawning of any importance takes place. Since nevertheless, despite the lack of tiny fry, the small cod grow up there, these must come from other localities where spawning occurs. The cod fry cannot come from the northern localities of West Greenland down to the Frederikshaab and Julianehaab districts, since the currents along the coast tend northwards. The greater chance is, that the fry are carried over from the spawning grounds at West and South Iceland. That such a drift does take place, is shown by Tåning (1937) who writes as follows in his paper on "Some Features in the Migration of Cod": "There are grounds for believing, therefore, that certain parts of the Greenland cod stock are brought as fry from Iceland, in the same way as the cod stock in the waters of North Norway and in the Barents Sea are partly recruited by fry from the Lofotens; this must certainly hold good for the larger part, if not the whole of the

East Greenland stock, but so far owing to various causes we have not succeeded in tracing the drift of the cod fry towards the south along the east coast down to Cape Farewell or round to the west coast, where we meet with a very rich stock of small cod in the southern districts, perhaps to a large extent of Icelandic origin." TÅNING mentions also, that racial investigations have shown, that the South Greenland cod resemble the Iceland stock of cod, though the characters investigated have on the whole slightly higher values. It is remarkable, as shown by the marking experiments, that the great emigration of Greenland cod about to spawn to the spawning grounds of Iceland consists for the most part of individuals from the Julianehaab and Frederikshaab districts.

But little is known regarding the growth conditions in the southernmost part of East Greenland. In the Angmagssalik district small cod of the I-, II- and III-groups were taken in 1927 and 1930. In the small south-east Greenland fjord Nanusek, ca. 60°30′ N. L., six small cod of the I-group were taken with the eel-seine in 1932. I am of the same opinion as TÅNING, that the small cod of East Greenland are carried over by the currents from West and South Iceland.

IV. Growth and Food.

A. Growth of the Cod at Greenland.

1. The Material.

In an earlier publication HANSEN and JENSEN (1931) have discussed the growth of the cod at Greenland on the basis of observations made in the years 1924—30. Further, in the annual reports on the fisheries investigations from 1935—39 (Beretninger og Kundgørelser; HANSEN 1935, 36, 37, 38 and 39) mention is made of the average lengths of the different year-classes of cod in the years investigations were carried out. In the *Annales Biologiques* also a survey is given of the average lengths of cod at Greenland and the average lengths of each age-group in the different year-classes (HANSEN 1943). Here we shall discuss the available observations specially dealing with changes in the growth of the cod at Greenland.

For the investigation of the age and growth of the cod in Greenland waters a large material of otoliths and measurements has been collected in the years 1924—1947. In the first years samples of scales as well as otoliths were taken, but age determination from the scales is very uncertain, when as here we are concerned mostly with older fish. In the later years only otoliths have been collected. For the 0-group measurements alone have been used and this method has likewise been employed in most cases for the I-group. Otoliths have been used for the older groups.

The measurement of the total length has been taken from the snout to the extreme end of the tail fin. As the latter is more or less forked, the lower arm has been considered the outermost. The measurements have been rounded off to the nearest whole cm. downwards. The averages are thus 0·5 cm. too low and this amount must therefore be added to obtain the true average. This however, has not been done here. In the case of the 0-group the measurements are to the lower whole mm. The samples of otoliths are collected in small envelopes on which are noted the locality date, length and sex, as also sometimes the weight and contents of the stomach. The material from 1924 was collected by Dr. phil. TÅNING, who in that year accompanied "Islands Falk" on its inspection cruise in West Greenland. The collections from 1925 and 1928 are respectively from the cruises of the "Dana" and "Godthaab". The samples from 1926 and 27, as from 1929 to 1933, were collected by the present author from the motor-boat placed at his disposal by the Greenland Administration for the fisheries investigations. From 1934 to 1947, in addition to the collections made by the author on behalf of the Greenland Administration, materials for the age and weight determinations were also collected at a large number of the principal fishery stations of West Greenland. The local fishery officials undertook the collections made at different times during the season. Why this was not done earlier was due to my desire to be quite certain, that the samples were collected in a proper manner and the measurements made correctly. It was not until 1933 that I was able to visit and instruct both Danes and Greenlanders at all the fishing places from which samples were desired. We have found that on the whole the samples have been collected correctly and the measurements carefully made. Where the measurements have seemed inaccurate or where there have been other errors in the samples, these have been discarded. There have been however very few cases of this kind.

A large part of the material from the banks has been collected from a number of Faroese cutters at the instigation of Dr. phil. Å. VEDEL TÅNING from "Kommissionen f. Danmarks Fiskeri og Havundersøgelser". During the whole war, though communications with Denmark had been broken, measurements and otoliths had been collected as usual at the various Greenland stations. This work was carried on chiefly on the initiative of the present Director ESKE BRUN, at that time governor.

At Angmagssalik collections were made in 1931 (502 samples) and 1938 (55 samples) by Colony-manager HEDEGAARD and mag. scient. BERTELSEN respectively. Young cod especially of the I-, II- and III-groups were taken in the eel-seine and by small jigs and altogether 2,274 otoliths obtained from both East and West Greenland. Of larger cod, caught with

Table 15. **Size of the 0-Group of Cod, in mm.**

Date	1.—15.5	16.—31.5	1.—15.6	16.—30.6	1.—15.7	16.—31.7	1.—15.8	16.—31.8
1926	—	6·0 (4)	6·4 (14)	8·3 (23)	11·3 (57)	—	18·0 (96)	—
1927	5·0 (30)	6·3 (3)	7·4 (47)	—	9·3 (7)	—	—	26·0 (9)
1930	—	—	7·0 (1)	6·5 (2)	—	—	—	—
1931	—	—	—	8·0 (2)	10·8 (6)	13·5 (13)	—	—
1932	—	—	8·8 (48)	—	—	—	—	—
1933	—	—	—	7·7 (3)	—	12·0 (1)	—	—
1934	—	—	—	7·7 (51)	8·6 (78)	12·7 (9)	—	—
1935	—	6·0 (6)	5·2 (54)	7·6 (31)	8·3 (8)	—	10·5 (2)	—
1936	—	—	6·7 (3)	8·9 (513)	11·5 (2)	—	20·0 (1)	23·0 (1)
1937	—	4·9 (10)	7·2 (11)	7·8 (4)	—	—	—	—
1938	—	—	—	6·0 (28)	7·3 (38)	7·5 (43)	—	30·0 (1)
1939	—	—	5·4 (81)	6·4 (17)	7·0 (20)	—	—	11·7 (3)
Average ...	5·0	5·6	6·5	8·5	9·1	9·4	18·0	22·4
Total.....	30	23	259	674	216	66	99	14 = 1381

the ordinary gear used in the commercial fishery, 50,844 specimens in all were taken at West Greenland. Small and large together thus made up 53,118 specimens.

The smallest number of otoliths was collected in 1925, namely 108, the largest 6,569 in 1934. All the otoliths collected were examined to determine the age of the cod. As mentioned above, the otoliths furnished excellent material for these determinations, as the winter and summer rings are as a rule sharply marked off from each other. The age of the cod, right up to the twentieth year, could in most cases be readily determined by this means. Yet one can hardly expect 100 % accuracy in such investigations; for the present material we may take it, that from 5 to 10 % could not be determined with complete certainty.

The actual determinations were made in a very simple manner. The otolith was broken across the middle and with tweezers one half was dipped in a small Petri dish filled with xylol; the broken surface was then examined under the binocular microscope by oblique light; magnification ca. 20. In cases of doubt both otoliths were examined. The broken surfaces of the otoliths have as a rule been so clear and smooth that the rings were sufficiently apparent. When this was not the case, the surface was lightly ground on a fine carborundum stone. Very few had to be embedded in plaster and ground on a machine as in Dr. TÅNING's method.

All the samples up to 1939 have been examined by the present author. Most of the material from the years 1940—47 has been determined by Miss ANNA OVERGAARD. The material collected at Greenland during the season (May till October) has been examined the following winter at the laboratory in Copenhagen; a small part however on board the research-vessel. Fresh material has not been used, as the otoliths when fresh have a glassy look and the summer and winter rings are not so sharply marked as in the material dried for several months.

Age determination by means of the otoliths has presented little difficulty on the whole; yet an exception has to be made in the case of a no small material collected at times in the Godthaab Fjord, especially at Kapisigdlit. In many of these otoliths the ring formation was somewhat indistinct and the age determination thus rendered difficult. This type of otolith greatly resembles that found in the coastal cod of Norway (ROLLEFSEN 1932). The determination could be made usually, yet one must reckon with a greater percentage of failures than in the case of the material from other Greenland localities.

In addition to the investigation of the age and growth, the otoliths have been used to determine the composition as to year-classes of the cod stock in the various years and through this the greater or less importance of the different year-classes in the cod catches, a subject that will be dealt with in a later section.

2. 0-Group.

To distinguish between the different age-groups of the cod the usual nomenclature has been used in the following: 0-group, I-group, II-group etc.; a cod of the 0-group is thus in its first year. As the hatching of the eggs is spread over a long period we have to fix a definite date for the beginning of the I-group; this has been taken as the 30. April. Thus a cod belongs to the 0-group from hatching until 30. April of the following year. From 1. May it is placed in the I-group until May 1. of the next year, when it joins the II-group and so on.

The lengths of the 0-group specimens, taken with the ring-net, are given in Table 15. Some of the young were measured immediately after capture, but most were measured after they had been preserved in formaline, often for a long time, several years. The measurements were taken to the lower whole mm. The smallest specimens taken in the ring-net were 4 mm. in length. Altogether 1,381 specimens were measured, as given in Table 15. The figures in brackets give the number of specimens on which the average is based. The table also shows the average lengths in the different months in all the years. These are somewhat variable through-

Table 16. Average Lengths of the different Age-Groups of Male and Female Cod from the northern Districts (N) and the Julianehaab and Frederikshaab Districts (S), calculated from material for the years 1931—39.

Age-Group	N				S			
	♂♂		♀♀		♂♂		♀♀	
	n	A	n	A	n	A	n	A
IV	604	52·5	638	52.1	362	49·5	395	50·5
V	1193	62·1	1282	62·1	791	59·7	833	59·6
VI	749	68·4	820	69·7	759	66·9	844	67·8
VII	936	72·0	1082	74·2	715	72·1	828	73·0
VIII	955	77·1	1090	79·7	809	73·1	1025	74·3
IX	656	82·0	893	85·1	388	78·4	489	79·9
X	669	83·3	859	86·7	551	78·6	792	80·5
XI	433	86·5	567	91·0	165	81·8	301	85·4
XII	518	88·4	656	93·8	113	83·7	212	86·8
XIII	384	89·2	493	94·5	75	84·7	117	90·4
XIV	222	95·0	284	101·6	35	87·1	52	91·0

n = numbers. A = Average length.

out, due possibly to the fact, that the larvae are hatched earlier or later according to the earlier or later warming of the water.

The material is rather too small and scattered to give clear information on the differences in growth in the different years. In some years, for example, there are several breaks when none of the 0-group was caught. Yet it would seem, that the growth in the years 1938 and 39 has been slower than in the other years, the average being quite low.

From 5·6 mm. in May the size increases evenly to 9·4 mm. at the end of July. In August the average length mounts to 18 mm.; an increase that may be ascribed to the shortcomings of the material, since in the period 1.—15. August the material is almost entirely from the year 1926, when the 0-group seems to have had a very strong growth. The absence of large numbers in the periods 1. August—15. August and later is due, partly to the young cod having reached such a size that they escape the ring-net, and partly to the young cod seeking the bottom at this size. These small cod are not taken by the eel-seine either, as they are so small they can as a rule escape through the meshes. Large quantities of the 0-group have only been taken by the seine in 1929, in Unartok and at Nanortalik in the Julianehaab district. These catches unfortunately were not dealt with in the determinations. A few small ogac may be amongst them, as they resemble the young cod so closely, that it is almost impossible to separate the species.

3. I- II- and III-Groups.

These three age-groups of cod are caught near the shore in the eel-seine or by means of small jigs. The latter method is specially useful for the III-group, of which it is on the whole more difficult to obtain a representative material than of the two younger groups, the larger individuals often keeping to the deeper water, whilst the smaller remain closer to the shore, often along with shoals of cod belonging to the I- and II-groups. The I-group as a rule is easily separated from the others by the measurements alone, the lengths of the largest of the I-group seldom overlapping those of the smallest of the II-group. On the other hand, we find overlapping between the II- and III-groups. It has thus been necessary to make many age-determinations (otoliths) for the cod of these two age-groups, whereas but few were necessary for the I-group.

Regarding the distribution of the sizes belonging to the age-groups I—III, see Fig. 29, p. 63.

The average lengths of the cod of the I-group vary from 8.5 cm. (Ritenbenk 8. July 1936) to 16·2 cm. (Sukkertoppen 18. August 1927). The total average for ca. 11,000 measurements was 12·3 cm.; the average from 5,824 measurements of cod taken in the districts from Godthaab northwards was 11·9 cm.; for the Frederikshaab and Julianehaab districts the average was 12·9 cm.

In the case of the II-group the lowest average length was 21·0 cm. (Kapisigdlit 4. June 1936) the highest 27·3 cm. (Tukingasok, N. of Julianehaab, 29. July 1937). We exclude here the average 33·6 cm. for the samples from Sukkertoppen and Godthaab in 1924, as these cod were taken always by hook and line, to the exclusion probably of the smaller individuals. For cod of the II-group from localities along the whole coast the average length was 24·6 cm. The average for 534 small cod of the II-group from the more northerly districts was 24·0, whilst 370 specimens from Julianehaab and Frederikshaab districts had an average length of 24·8 cm.

Of the II-group at Greenland 1,452 specimens in all have been examined. The 1,046 taken in the more northerly parts had an average length of 39·3 cm., whereas 406 taken in the Julianehaab and Frederikshaab districts had an average length of 35·7 cm.

The average for the III-group has thus been 3·6 cm. higher in the more northerly cod than in the southern, whereas for the I- and II-groups the average was slightly higher in the two southern districts. Con-

sidering however that these are very rough calculations, the material coming from several years and from different localities in the various years and from different times of the season, we cannot conclude that the differences found stand for an actual difference in growth in the two areas. On the contrary, the extent of the differences is so narrow, that we may rather believe, that the growth is much the same in the two areas, so far as these young age-groups are concerned. Nor does there seem any great difference in growth during the first years between the different age-groups of cod.

The annual reports on the fisheries investigations give the size-distribution of small cod taken in each year; the average lengths for each year-class in the age-groups I—III have also been given earlier (Hansen 1943, pp. 112 and 113).

4. Growth of Cod in older Age-Groups.

The growth of the cod at Greenland has been dealt with on earlier occasions by Hansen and Jensen 1930 and 1931, in the annual reports on the fisheries investigations at Greenland, in reports and notices concerning the Greenland Administration (Statist. Oplysn. Grønland I). Further, Hansen (1943) has given the average lengths of the various age-groups of cod in the years 1924—39 as also the average lengths for the separate year-classes. In these publications the males and females are taken together as a rule. As the lengths of the females are on the whole greater than those of the males (cf. Beretn. vedr. Grønlands Styrelse 1942, No. 1, p. 411), a fact known from other areas where the cod occurs, the two sexes are dealt with separately in the following discussion.

The differences between the two sexes at different ages can be seen from Table 16. For the IV- and V-groups the lengths are the same; for the older groups the females are the larger. The difference is greater for the older groups than for the younger.

a. Differences in Growth of Cod in different Localities of Greenland.

In 1930 and 1931 Hansen and Jensen gave the growth curves of cod for the northern districts and for Julianehaab, showing that the growth in the north is somewhat greater than in the Julianehaab district. During the investigations of recent years, however, it has proved that the average lengths for the different age-groups may vary considerably in the different years, as illustrated in Fig. 12. Here we have the average lengths of female cod belonging to age-groups between IV—XIV from different localities in the years 1932, 1934, 1939 and 1945. The averages for each locality are connected by curves. That females are chosen here and in the following is due to the fact, that the material for these is the larger; the males show exactly the same conditions.

The average lengths for the age-groups of cod from Julianehaab and Nanortalik are considerably lower than those for the corresponding age-groups from the other localities in 1932 and 1934. In 1934 especially they are very low for Julianehaab and Nanortalik, but there is not such a great difference in the averages for the northern localities. In 1939 Julianehaab and Nanortalik show decidedly higher values, whereas Godthaab Fjord, which in 1934 was but little lower than North Greenland and the banks, is now considerably lower than Julianehaab—Nanortalik. In 1945 Julianehaab comes very near North Greenland and Sukkertoppen, whilst Godthaab Fjord has moved very far down below the others. The cod from this locality are almost like dwarfs by comparison with the cod from the other localities.

b. Differences in the Average Lengths of the Age-Groups of Cod in the different Years.

Fig. 13 shows for each area the average lengths of the age-groups in the different years. In North Greenland and Sukkertoppen the averages for the different age-groups are seen to have remained very constant over several years. The younger age-groups in 1939 are somewhat lower however than the corresponding groups in the three earlier years. In 1945 all the averages are considerably lower than the corresponding averages in the other years. For example, the groups IX—XIII lie about 8 and 12 cm. lower. In 1939 the averages for Godthaab Fjord are throughout lower than in earlier years; in 1945 much lower. For the VIII—XIII groups the difference in the average from earlier years is about 17 to 24 cm.

From Frederikshaab only the years 1939 and 1945 contain material of suitable sizes. Here also, as the figure shows, the average lengths for the older age-groups are quite considerably lower than the averages for the corresponding groups in 1939, even though the difference is not so enormous as in Godthaab Fjord. At Julianehaab the conditions are very different from those in the northern areas. The average here is lowest in 1934, but highest in 1937. In the other years the averages for 1946 lie nearest those for 1934 and are thus fairly low. For Nanortalik the conditions greatly resemble those found at Julianehaab.

We thus find very great fluctuations in the average lengths of the age-groups in the different localities of the Greenland area where investigations were made. These fluctuations have great importance in the product of the fisheries, a decrease in average length meaning naturally a decline in the weight. Considering the females of the VIII-, IX- and X-groups, for example, we find that in North Greenland these in 1934 had the averages ca. 82, 84 and 89 cm.; in 1945 the corresponding averages were about 73, 77 and 78 cm. The corresponding weights were in 1934 about 5, 5·7 and 6·5 kg., in 1945 only about 3·5, 4·2 and 4·5 kg. This meant a drop in weight of $1^1/_2$ kg. for the VIII- and IX-groups and of 2 kg. for the X-group in 1945 by comparison with 1934.

In the case of Godthaab Fjord the difference is

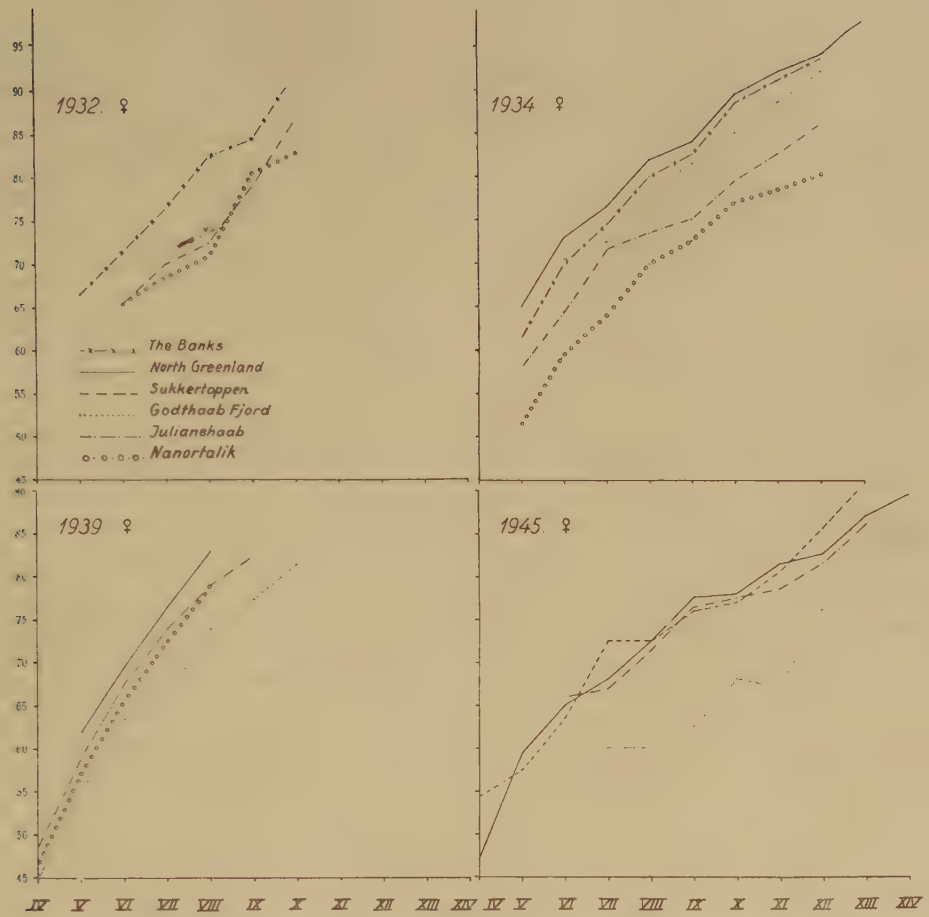

Fig. 12. Average Length of Cod (♀) belonging to different age-groups in the years 1932, 1934, 1939 and 1945; from the banks, North Greenland, Sukkertoppen, Godthaab Fjord, Julianehaab and Nanortalik.

naturally much greater. Taking the VIII- and X-groups, for example; these in 1934 had average lengths of about 79 and 85 cm., but in 1945 about 60 and 68 cm., with the corresponding weights respectively 5 and 6 kg. and 2 and 3 kg., thus a difference of 3 kg. This means that the weight of the VIII- and X-groups has declined from 1934 to 1945 by respectively 60 % and 50 %.

c. Differences in the Average Lengths of different Year-Classes of Cod.

Fig. 14 shows the average lengths of female cod in various age-groups of certain year-classes for North Greenland, Sukkertoppen and Nanortalik. The year-classes chosen are those which have been of importance in the stock of cod at Greenland and for which we have a fairly large material. Considering the data for North Greenland and Sukkertoppen we readily see, that the average lengths for the year-classes 1924, 1926 and 1929 lie very close together and are higher than the averages for the year-classes 1932, 1934, 1935 and 1936, in which the averages for corresponding age-groups are much the same. The difference amounts to about 10 cm. and means, that the year-classes 1924, 1926 and 1929 have had a stronger growth than the four younger year-classes. What is true for North Greenland and Sukkertoppen holds good also for the Godthaab Fjord, where the differences in growth between the older and younger year-classes have been even greater. But from Godthaab Fjord we do not have so many years' observations in continuous years. In the Julianehaab district the differences in the year-classes have not been so marked as in the northern areas. At Nanortalik the year-classes 1924, 1934 and 1936 had a slow growth, that of the 1931 and 1932 has been better. For Julianehaab the conditions have been almost the same as at Nanortalik.

The great fluctuations in the average lengths of the different age-groups, specially marked in the northern districts, is thus due to differences in growth of the different year-classes. There has been, for

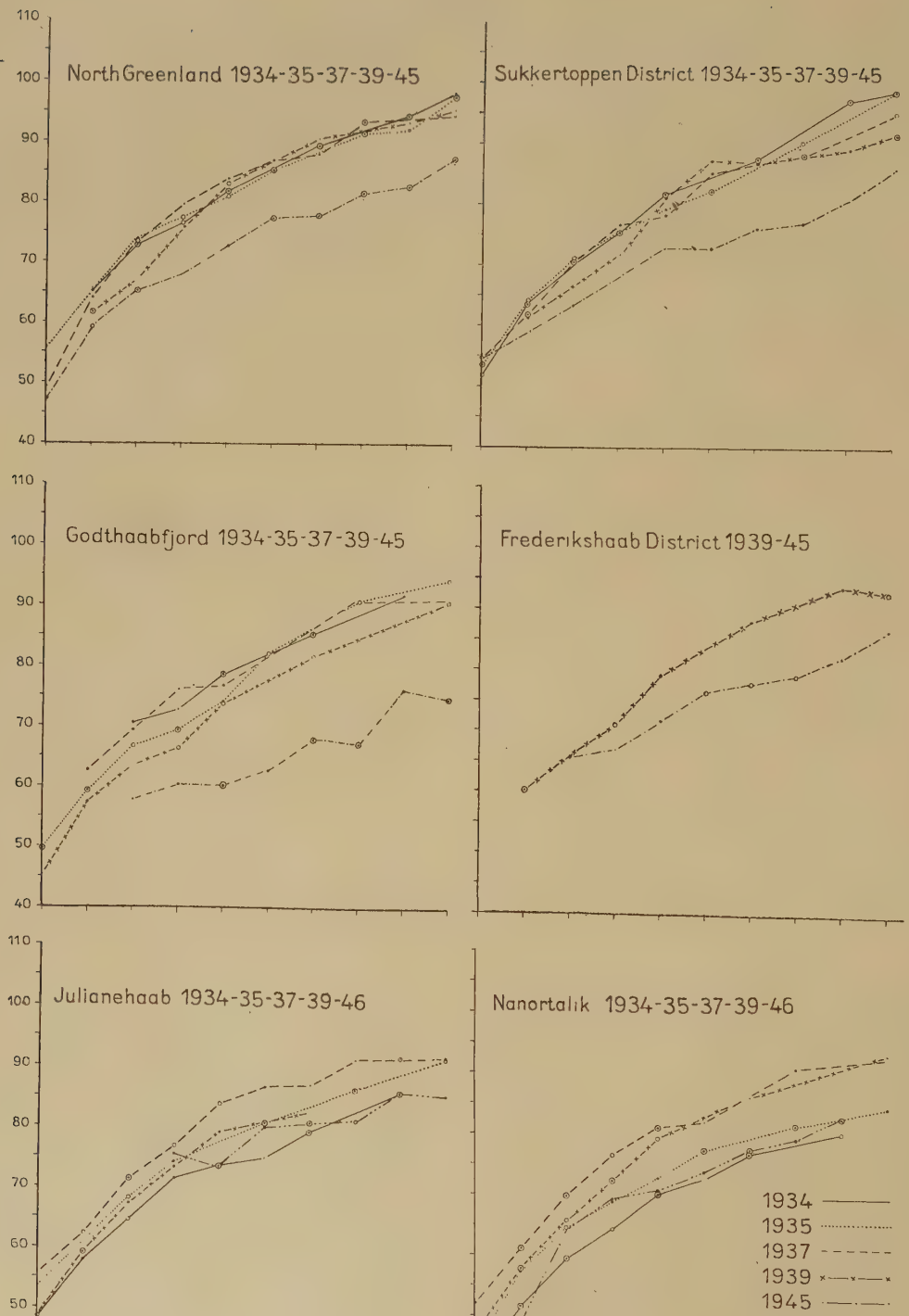

Fig. 13. Average Length of the Age-Groups IV—XIII in the years 1934, 1935, 1937, 1939, 1945 and 1946, at different localities of West Greenland. The signatures black spot, open circle and circle with spot indicate that the averages are calculated from the following number of individuals: 5—24, 25—49 and 50 and more, respectively. No averages are given calculated from less than 5 individuals.

example, a great decline in growth of the 1932 and younger year-classes in the northern districts. As noted in the previous section, there has not been any decrease of the average lengths in the first three age-groups. It is not until the age of 6—7 years, that differences show themselves in the average lengths.

The cause of the smaller growth in the younger year-classes might be imagined to come from: 1. hydrographical conditions; 2. overcrowding and hence lack of food; 3. earlier beginning of maturity with cessation of growth and with this a greater mortality or emigration to other areas of the largest individuals of the age-groups; 4. immigration of more slowly growing cod from other areas.

1. With regard to the hydrographical conditions, there might possibly have been a lowering of the temperature and thus less favourable conditions in regard to food and growth. As mentioned earlier, we have had a warm period since about 1920 and this period has not yet ended according to the post-war hydrographical observations. Yet the year 1937 seems to have been somewhat colder than usual and 1938 especially was an extremely cold year, with very low temperatures in the water, so low that many cod died in the course of the spring. In Holsteinsborg, for example, many large dead cod were brought up in the prawn fishery (Hansen, 1939 and Jensen, 1939). By contrast 1939 was a very warm year.

Dunbar (1946), on the basis of his observations during the war, is of the opinion that the warm period culminated in the middle of the thirties and is now declining. However, continuous hydrographical observations in Greenland waters are lacking to make certain of this point. The possibility cannot be excluded, that the cold year 1938 and the lower temperatures in the beginning of the forties may have had some influence on the growth of the cod.

2. With regard to the question of overcrowding, it can be said at once that the cod stock has been abundant. In recent years the Greenland fishery has yielded greater quantities than ever before. This may have been due to some extent to more intensive fishing with greater use of small motor boats and long-lines and the erection of more new and larger fish-houses. At the same time, with the increase in the fishing by the Greenlanders, the fishery by other countries, several times greater in the thirties than that of the Greenlanders, was practically stopped during the war. The drain on the stock has thus been considerably less for a number of years. At the same time four good year-classes, 1931, 1932, 1934 and 1936, have made themselves greatly felt. It is worth pointing out, that the decrease in growth has been specially marked in the Godthaab Fjord, which is a closed area with its own stock of cod, thus presenting a greater possibility of overcrowding. It has been noticed in this fjord that the cod, in addition to growing more slowly, have also become very thin. This has been readily seen in sorting the finished saltfish, a greater number being required to make up the 50 kg. cases than before. This applies to all the sizes con-

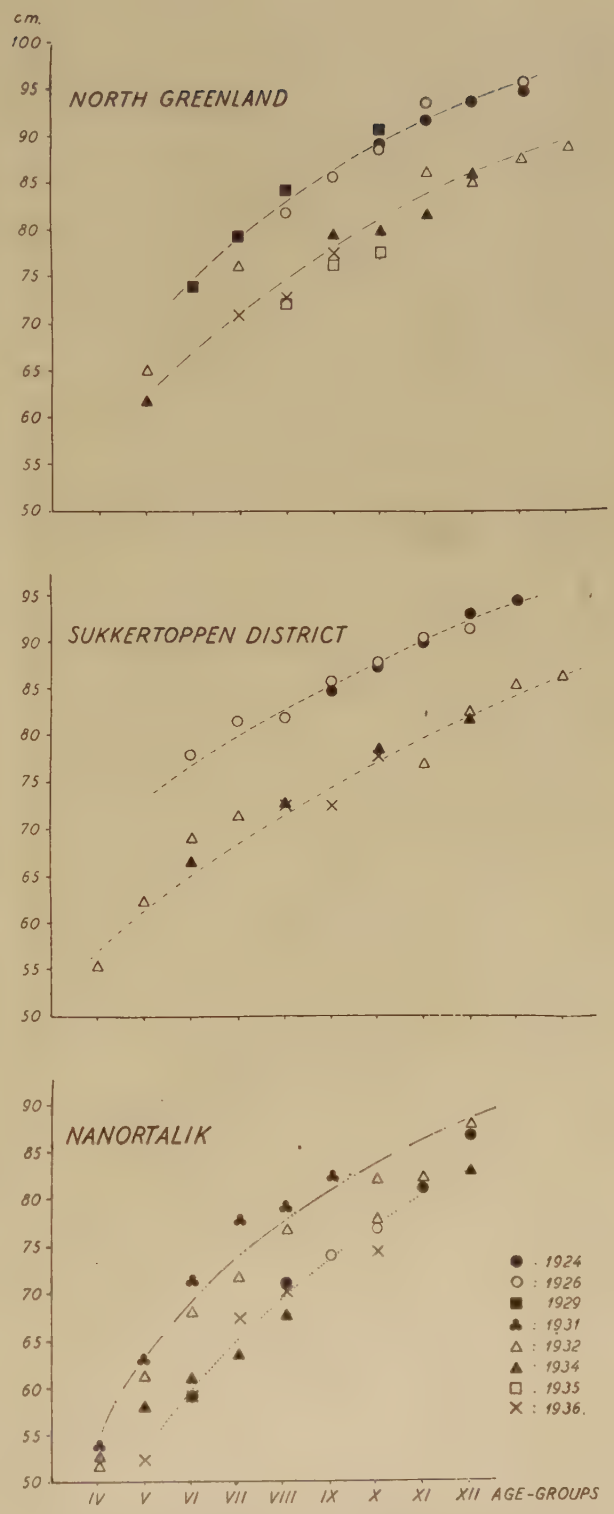

Fig. 14. Average Length of eight different Year-Classes of Cod in different localities of West Greenland.

cerned. The food that means most for the nourishment and growth of the cod is certainly the capelan (*Mallotus villosus*). It is possible that a reduced occurrence of this small fish may have greatly influenced the decline in weight of the cod. According to several Danes and the Greenlanders there have been for years far fewer capelan than earlier in the more northerly districts, whilst it has shown normal occurrence in most years in the Julianehaab district. These statements are so uncertain, however, it is not possible to come to any definite conclusion.

3. It cannot be excluded that an earlier beginning of maturity and therewith stoppage of growth has influenced the slow growth of the younger year-classes. In an earlier section (p. 27) it has been noted, that examination of so-called spawning zones in the otoliths has proved, that an actual change has occurred in the age when maturity begins. Whereas the year-class 1917 in the northern districts had 60 % of first-time spawners in the ages 9 to 11, and the year-class 1922 64·7 % in the ages 8 to 10 years, the year-classes 1934 and 1936 had 60·6 and 64·6 % first-time spawners at an age of 7 years. It is well-known, that the growth becomes slower when maturity sets in. When this occurs earlier for the younger than for the older year-classes, it may perhaps account for the slower growth of the younger year-classes.

In order to show the influence which an early beginning of maturity may have upon the stagnation of growth, calculations are given in Table 17 of the average lengths of cod of the year-classes 1934 and 1936 (age-groups XIII and XI) which have spawned for the first time as 6, 7, 8, 9, and 10-year-old fish.

Table 17. Average Lengths of Cod at First-Maturity.

Northern Districts

Year-Class (Age-Group)		Age at First-Maturity 6 A	n	7 A	n	8 A	n	9 A	n	10 A	n
1934	♂♂	81·7	(20)	81·5	(143)	81·8	(84)	82·6	(45)	—	
(XIII)	♀♀	83·4	(19)	84·5	(239)	85.1	(146)	85·4	(77)	86·0	(22)
1936	♂♂	76·3	(18)	76·9	(96)	77·1	(82)	77·1	(11)	—	
(XI)	♀♀	79·9	(18)	79·6	(130)	79·9	(102)	82·5	(19)	—	

Southern Districts

Year-Class (Age-Group)		Age at First-Maturity 6 A	n	7 A	n	8 A	n	9 A	n	10 A	n
1934	♂♂	82·2	(13)	80·8	(49)	80·3	(45)	80·5	(34)	81·9	(8)
(XIII)	♀♀	81·5	(12)	83·9	(107)	84·1	(101)	86·5	(52)	89·2	(12)
1936	♂♂	76·3	(6)	77·3	(39)	78·7	(37)	81·2	(11)	—	
(XI)	♀♀	78·3	(6)	79·2	(80)	79·6	(77)	81·3	(22)	82·8	(5)

It will be seen that the average lengths of cod that have spawned at an early age, are generally somewhat smaller than those of cod that have spawned at a higher age. The differences are, however, generally quite small compared with the great differences in growth observed in the various year-classes. This would indicate that the early beginning of maturity in the younger age-classes is not the only cause of their stagnation of growth.

4. That there may be an immigration of cod from Iceland over to Greenland, at least in certain years, has been proved by the marking experiments (p. 59). Presumably however, it is a question of cod which have grown up at Greenland and have returned there after spawning at Iceland. The investigations have shown (Hansen, Jensen and Tåning 1935, pp. 84—86), that the cod which are approaching first-maturity and migrate to Iceland, have a slower rate of growth than the cod which remain at Greenland. It is conceivable, therefore, that the decrease in growth for some year-classes results from the migration of large numbers of these year-classes to Iceland, spawning there and returning to the Greenland waters. These cod would then affect the average lengths of the age-groups to which they belong, bringing them lower.

I am inclined to believe, that the cause of the slower growth of the cod in recent years is to be found in a combination of the above-mentioned factors. It seems most probable, that shortage of food, whether from overcrowding or from a scarcity of the principal food-species, has been of great importance. In support of this we have the investigations in Godthaab Fjord, where the cod in recent years have not only grown more slowly but have become much thinner at the same time. The earlier inception of maturity has also had some influence on the rate of growth.

No decline in the rate of growth has been noticed in the case of the three youngest age-groups. Their average lengths have been almost the same in the different year-classes. This can be explained, whether we take lack of food or earlier beginning of maturity as the cause of the great decline in the rate of growth. The youngest age-groups live mainly on other organisms than the older cod. Bottom-animals like worms, molluscs and small crustaceans play a great part in the food of the young, whilst the principal food of the older cod is fish (capelan and sand-eels). But where the organisms the young feed on, may be considered to occur in uniform quantities in the various years, there is a greater probability for variations in the principal food sources of the older cod. These consequently are more subject to lack of food and thus decline in growth more than the younger.

With regard to limitation of growth when maturity sets in, it is evident, that this can only show itself when the individuals have reached an age near the beginning of maturity. Consequently it does not affect the younger age-groups.

Rollefsen (1947) has given a curve showing the variations in length of the age-groups VIII—XIII in the years 1932—45 for the Norwegian spawning cod at the Lofotens ("Skrei"). It appears that the average lengths were low in 1932, about 84 cm., and thereafter rose to about 92·5 cm. in 1936. Then they fell steeply till 1945, to about 85 cm.; Rollefsen ascribes these variations in the growth to varying conditions of food on the feeding grounds of the cod.

5. Growth Conditions in different Fjord Populations.

In a later section it will be mentioned, that local populations occur in certain fjords and that these differ from the cod in the coastal regions, among other things in number of vertebrae and rays in D_2. Such local stocks are found in the Ikertok Fjord in Holsteinsborg district and in Kangia Fjord in the Sukkertoppen district. The growth in these fjord populations differs from what we find in the cod of adjacent localities in the coastal region.

When discussing the spawning conditions in Ikertok Fjord it was mentioned, that a local stock was found there in the spring, spawning at a great depth below the ice, whilst later other cod migrated into the fjord from outside. In 1934 material was collected of otoliths and measurements for age and growth determinations in two periods, 1.—15. May and 29. May—6. June. In the first period only cod belonging to the local stock were found, whilst in the second a large immigration of cod from outside had taken place. The average lengths of the cod belonging to different age-groups in the two periods were as follows.

Table 18 A. Average Lengths in two Periods in Ikertok Fjord.

	V Av. L.	No.	VIII Av. L.	No.	X Av. L.	No.	XII Av. L.	No.
1.—15.5								
♂	56·7	49	74·8	19	81·5	4	86·0	3
♀	60·4	67	76·4	23	96·7	6	91·0	2
29.5—6.6								
♂	63·9	25	78·3	40	87·6	31	91·8	22
♀	64·6	46	85·0	30	90·7	41	98·4	17

It will be seen, that the average lengths for corresponding age-groups are lower in the first period than in the second. The local population has thus a slower growth.

Comparing now the average lengths of cod from the Kangia Fjord in 1934 with those from the other part of Sukkertoppen district in the same year, we find that the Kangia cod have the lowest average lengths.

Table 18 B. Average Lengths at Sukkertoppen and Kangia.

	V Av. L.	No.	VI Av. L.	No.	VIII Av. L.	No.	X Av. L.	No.
1934, Sukkertoppen District								
♂	62·9	38	69·5	18	78·8	68	83·4	50
♀	63·5	50	70·0	28	81·7	70	87·2	53
1934, Kangia								
♂	60·1	22	66·7	44	71·3	76	83·1	8
♀	58·1	10	67·7	27	76·0	50	85·9	11

The local fjord populations in Ikertok and Kangia are thus distinguished from the cod in the coastal area by a slower growth.

Similar investigations at Atangmik in Angmasivik Fjord in the Sukkertoppen district showed, that the cod in this fjord were not different from the coastal cod in the matter of rate of growth. We shall see also in a later section, that the number of vertebrae shows no difference between cod in Angmasivik and in the coastal areas. A separate population does not seem to occur in this fjord; if it does, it becomes mixed to a very great extent with cod from outside.

The growth of the cod in Godthaab Fjord has been discussed in the previous section. It has been shown for these cod, that the growth is considerably slower in the younger year-classes than in the older, with the result, that the average lengths for the different age-groups have greatly decreased since the middle of the thirties. The cod in Godthaab Fjord are now much smaller than cod of the same age at the coast.

B. Food of the Cod at West Greenland.

The food of the cod at Greenland has been dealt with in an earlier paper (Hansen and Jensen 1930). Since that work appeared, further investigations into this matter have been made at several localities in West Greenland.

Many of the cod used in the measurements and age determinations from the otoliths, have also been cut open and the contents of the stomach examined. In most cases no counting has been undertaken of the number of individuals in the various kinds of food, nor has any measurement been made of their amount or weight.

Table 19 only shows, therefore, how many cod stomachs have contained the food-stuffs mentioned. As the 1930 publication did not give any tables for the food investigations carried out in the years 1925 to 1929, these have been included in Table 19 along with the results for later years.

The cod examined have been caught partly on hand-line and hook, partly by long-lines. The catches include both pelagic cod, i. e., taken near the surface and those caught at the bottom. The results given in the table are from cod of from ca. 50 cm. to over 1 m. in length. An exception is the sample from Sukkertoppen on 19.—26. August 1927, which consists mainly of smaller cod. The localities where investigations were made, include fjords, coastal waters and the banks. In addition to the places noted in the table there have been others, where the stomach contents have been examined in part of the catches. As a rule only some of the individuals in the catches have been examined as samples and it has thus not been possible to include them in the table. This procedure has been especially adopted in the cases where the food has been mainly of one certain kind, far exceeding the rest. This has often happened in the early summer, for example, when the capelan is practically the only food of the cod, especially in the fjords. In consequence of this the capelan is not at all well represented in the table.

The investigations show that the cod at Greenland, as at all other places, is practically omnivorous, such a number of different kinds of animals make up their

Table 19. **Food Contents of the Cod at Greenland.**

	Fylla Bank 19. 6.–5. 7. 1925	Fiskenæs and Dana Bank 6.–11. 7. 1925	Lille Hellefiske Bank and Fylla Bank 13.–21. 7. 1925	Kapisigdlit (Godthaab Fjord) 26. 6. and 2. 7. 1926	Kugssuk (Godthaab Fjord) 1. 7. 1926	Korkut (Godthaab Fjord) 8. 7. 1926	Fiskenæs (Godthaab Dist.) 22. 7. 1926	Ikamiuts Kangerdluarssuk (Sukkertoppen Dist.) 3. 8. 1926	Napassok (Sukkertoppen Dist.) 6. 8. 1926	Angmasivik (Sukkertoppen Dist.) 8. 8. 1926	Kangamiut (Sukkertoppen Dist.) 4.–5. 5. 1927	Sukkertoppen (small Cod) 19.–26. 8. 1927	Lille Hellefiske Bank October 1928	The Sounds at Cap Farewell September 1929	Lichtenau Fjord 30. 9.–17. 10. 1929	Julianehaab 11.–17. 7. 1930	Frederikshaab 3.–23. 9. 1930	Kangamiut 17.–19. 8. 1931	Godthaab 16.–24. 8. 1933
No. of Cod	78	82	63	70	42	34	70	108	25	80	41	35	31	267	82	83	181	18	240
Empty stomach	5	14	6	7	11	9	7	35	2	10	2	3	—	48	11	12	18	—	—
Mallotus	—	3	1	19	28	9	19	18	13	5	29	21	—	16	1	1	11	2	124
Ammodytes	7	1	18	—	—	—	—	—	—	—	—	—	4	—	—	—	—	4	18
Cod	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	8	6	—	—
Drepanopsetta	7	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cottids	3	2	8	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greenland Halibut	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3	—
Other Fish	18	1	17	19	—	—	—	24	1	3	5	—	3	37	9	14	26	6	4
Pandalus	5	34	32	17	2	—	17	2	5	22	5	—	10	126	37	11	26	4	22
Crangon	16	2	5	—	—	—	—	—	2	1	—	—	—	3	1	—	2	1	1
Hyas	65	58	48	7	1	—	7	1	3	4	4	—	12	1	9	16	38	6	29
Larvae of *Hyas*	—	—	—	—	—	13	—	35	—	26	—	—	—	—	—	—	—	—	—
Amphipods	4	9	—	7	1	4	7	4	—	1	—	—	17	30	4	19	12	—	5
Euphausids	—	—	—	—	—	—	—	—	—	1	12	—	—	63	14	9	61	2	32
Mysids	—	—	—	—	—	—	—	—	2	—	—	—	—	19	2	—	2	—	—
Caprella	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	2	—	1
Ctenophores	—	—	1	1	—	5	1	4	3	26	1	12	—	39	5	3	44	2	30
Actiniae	—	—	—	—	—	—	—	—	—	—	—	—	—	14	6	—	2	1	1
Worms	33	22	15	—	—	2	—	5	1	8	—	1	10	21	20	5	11	2	8
Molluscs	1	2	2	—	—	—	—	1	2	3	1	—	3	—	4	1	1	—	2
Gastropods	—	—	—	—	—	—	—	—	—	1	—	1	1	12	—	2	—	—	—
Holothurians	3	2	1	—	—	—	—	—	—	—	—	—	1	3	3	6	2	—	6
Echinids	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	—	—	—
Asterids	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	1	—	—	—
Ophiuroids	—	—	—	—	—	—	—	—	1	—	—	—	4	1	—	—	—	—	—
Gonatus	1	1	1	—	—	—	—	—	—	—	—	—	5	6	—	1	4	1	1

food. Both pelagic and bottom animals are present and often plankton organisms as well as bottom animals are found in the stomach. Fish and various pelagic and bathypelagic Crustacea (*Pandalus borealis* especially, Euphausidae, Amphipoda (*Themisto*)) and such bottom animals as crabs and Polychaetes seem to be the principal food-stuffs. Fish and Crustacea especially are frequently found in the stomachs.

In the cod caught on the banks in 1925 crabs (*Hyas coarctatus*) dominated, whilst the cod taken in 1928 on the Lille Hellefiske Bank contained pelagic Crustacea for the most part.

Among the fishes the capelan (*Mallotus villosus*) is the most important. In the early summer, when the capelan in large shoals is spawning near the shore, it is eagerly pursued by the cod, which then becomes choke-full of this small fish. Both when the capelan before spawning swims in shoals over the deeper parts of the fjords and coastal waters and when it gathers near the shore to spawn, one can follow the cod hunting after them right up to the surface; frequently the cod spring right out of the water. During this period it is often difficult to catch the cod, as they are so full they pay no attention to jig or long-line hook, even when baited with fresh capelan. In Amerdlok and Ikertok fjords in the Holsteinsborg district, as also in Angmasivik Fjord in the Sukkertoppen district, the fishermen use nets for the cod, when the capelan nears the shore. The nets are set out from the beach, thus close inshore. Even when the capelan migrate out over deeper water after spawning, they are still pursued by the cod. For example capelan in fairly large numbers were found in the stomachs of cod off Nanortalik as late as 25. August in 1937, 26. August 1938 and 24. August 1939 and at Sangmissok on 30. August 1937; they were likewise found in the stomachs of cod on the Lille and Store Hellefiske Banks in August. On 3. September 1948 cod shoals were registered at the south-west coast of Disko (ca. 69°20′ N. Lat., 57°30′ W. Long.). Small quantities only could be taken with the hand-line. They were all filled with II-group capelan (10—14 cm.). The small *Mallotus* of the I-group, which only about 3·5—6 cm. long swarms in the surface near the

coast and in the fjords, is pursued by the smaller cod, which are often found quite full of these small, glass-clear fish.

In the Amerdlok and Ikertok fjords in the Holsteinsborg district the arrival of the capelan at the spawning grounds in the early summer gives rise to an extensive migration into the fjord of the cod which have just spawned outside. This leads to a very important fishery for the Greenlanders.

After the capelan the lance (*Ammodytes lancea*) is the most important food of the cod, especially later in the summer and mainly over the banks and in the coastal waters. Examination of cod stomachs, especially in Godthaab, Sukkertoppen and Egedesminde districts, gave in August large quantities of *Ammodytes*, both large and small specimens. In the Sukkertoppen district they were almost all large, whereas in Egedesminde the small seemed to be in the majority. In the middle of August large shoals of cod going northwards after the lance have been observed in several years over the Lille Hellefiske Bank. In 1931 the present author had the opportunity of observing directly this north-going migration, off Sukkertoppen on 5.—9. August and off Kangamiut on the 14. and 15. August. At the latter place especially the movement was clearly seen; the weather being calm and the water like a mirror. The migration was going on right at the surface with the dorsal fins of the cod in many cases showing above the water. Everywhere as far as one could see, the dorsal fins projected from the water and one could observe distinctly, that the shoals were moving northwards. Small and large flocks of *Rissa tridactyla* followed the shoals. Now and then when the gulls dived, one could see that they were after the lance. Two French boats and six Faroese cutters were fishing on the bank and through the telescope one could watch the fishermen continuously hauling in the cod over the side.

On 14. August the research-vessel marked 240 cod which had been taken by 2 men in 3 hours. They were so full of *Ammodytes* that these often sprung out of the mouth of the cod when brought on deck. On 17. August 150 cod were taken at the same place. The weather was then bad, with south-west gale and rain, and no cod were seen on the surface. Those caught were taken near the bottom and none had lance in the stomach. Fishmaster N. L. Nielsen at Sukkertoppen has reported, that he has observed in several years this mass-migration northwards of the cod after lance. The lance thus seems to play a very important role in the migration of the cod, at any rate over the marine banks of West Greenland.

The 1931 marking experiments showed, that in that year extensive migrations took place in a northerly direction. 1931 was likewise the year when the largest number of marked Iceland cod were recaptured on the West Greenland banks. As will be noted later, most of these recoveries were made far to the north on the Store and Lille Hellefiske Banks. Whether any great migration of lance at West Greenland can give rise to a migration on a large scale of cod from Iceland to West Greenland, is a matter naturally that cannot be decided on from the one year's observations.

In addition to *Mallotus* and *Ammodytes* various other fishes have been found in the stomachs of cod. Small specimens of cod and *Gadus ogac* are often taken in large cod; this applies also to small *Drepanopsetta* (long-rough dab) and various cottids. Lumpenus-species, *Centronotus fasciatus* and *Stichaeus punctatus* also are found now and then. None of these however has anything like the great importance of *Mallotus* and *Ammodytes*.

Greenland halibut about to change over to the bottom-stage may often be found in fairly large numbers in cod stomachs in August and September. This has been observed for several years at Sukkertoppen and in the sounds at Cape Farewell, for example by Ad. Jensen at the end of September 1909 (Jensen 1909).

The herring, which only occurred sparingly and locally in earlier years, became more abundant at Greenland in the thirties with a wider distribution. For example, it occurs in large numbers at several places in the Sukkertoppen, Frederikshaab and Julianehaab districts. Nevertheless, in contrast to the conditions at Newfoundland, Iceland and the Barents Sea, the herring plays no part in the food of cod at Greenland. In very few cases have small herring been found in cod stomachs; most cases occurred in Ikamiuts Kangerdluarssuk in the Sukkertoppen district in 1930 and in Neria, Frederikshaab district, in 1933.

Among the Crustacea *Pandalus borealis* is of great importance as food, especially for large cod living in deeper water. In the deeper part of Amerdlok Fjord the cod as a rule are filled with *Pandalus*. The same condition was found also at Jakobshavn in 1936 and in the Lichtenau Fjord in August in the years 1929, 1936 and 1938. In addition to *Pandalus* several species of *Spirontocaris* are usually present in smaller quantities. The same is the case with the species of *Sclerocrangon* and *Nectocrangon*. The Amphipoda are fairly evenly distributed in the cod stomachs in most localities; they seem mainly to be of some importance for the smaller fish. The species *Themisto libellula* is the one which is often taken in large numbers in the plankton nets. Euphausids, often found in swarms in the plankton, have only been seen in cod stomachs in less than half the localities; only in cod from the sounds at Cape Farewell in 1929 and off Frederikshaab in 1930 have they occurred frequently in the stomachs of cod.

Sometimes the larvae of crabs, both in the Zoëa and Megalops stage, have been found in the stomachs, especially of the smaller cod. Three stations are noted in the table, all from fjords, namely Korkut, Ikamiuts Kangerdluarssuk and Angmasivik, where crab larvae have been present in most of the cod stomachs. The small crab larvae are certainly an indifferent kind of nutriment, only taken when no other food was available.

Crabs, *Hyas coarctatus* and *H. araneus*, occurred

very frequently in the large cod taken on the banks in 1925; here they were quite dominant. They were also fairly numerous in the cod stomachs from the Lille Hellefiske Bank in 1928. Occasionally crabs also occurred in the stomachs from the coastal area, e. g., from Julianehaab and Frederikshaab in 1930. Crabs are usually present in the stomachs of cod from the banks and the outermost coastal area, less common in the fjords. They are of most importance for the large cod which mainly seek their food on the bottom.

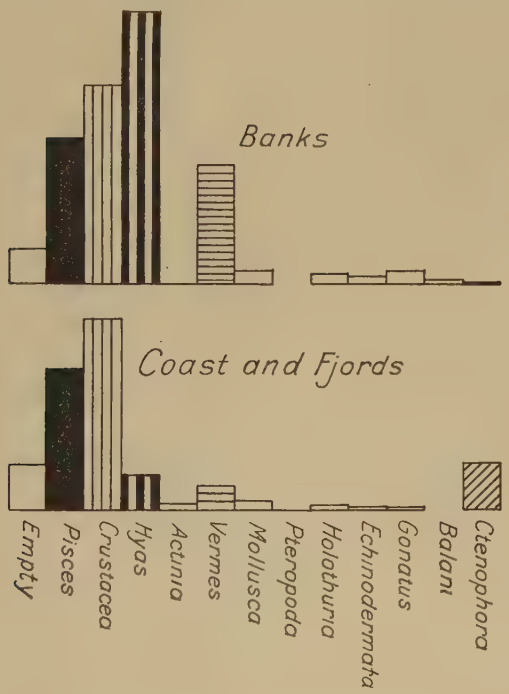

Fig. 15. Stomach Contents of the Cod.

Gastropods and molluscs are of subordinate importance as food for the cod in Greenland waters. Shells of mussels are rarely found in the cod stomachs. Sometimes pieces of siphon from *Mya truncata* occur. In a few cases only remnants of mussels are present. This was the case at Kutdligssat in August 1935, where one cod had its stomach quite full of the feet of *Cardium groenlandicum*. Young of the ink-fish (*Gonatus fabricii*), according to the table, seldom occur in the cod stomachs, but the table is misleading in this regard, as the cuttle-fish was found even in very large quantities in the stomachs of cod taken in July, August and September at Sukkertoppen and Godthaab. *Gonatus* is certainly of far greater importance as food than Table 19 would indicate, at any rate in certain years.

Pteropods are of subordinate importance at most places. In Umanak Fjord, where the large, black *Limacina helicina* is the dominant form in the plankton, a couple of smaller cod were taken in 1936 with this pteropod in the stomach, which had the effect, that the cod had the characteristic, penetrating smell of the pteropod and were quite uneatable. The same was the case with a number of *Gadus ogac* caught in the fjord. According to reports from Umanak a good many cod have been present in the fjord since 1940, also in the winter when some were fished below the ice, and many of these were unusable from their contents of pteropods.

In a few years pteropods have been found in fairly large quantities in the stomachs of cod taken on the Store and Lille Hellefiske Banks. This has been the case in 1934 and 1935 according to reports from Faroese fishermen. In July—August 1947 there was an extraordinary number of pteropods in the stomachs of the cod, not only from the banks but also in the coastal area in the Holsteinsborg and Sukkertoppen districts. In the Amerdlok Fjord at Sarfanguak also the cod were full of pteropods. The cod were quite uneatable in fresh condition.

In their work of 1931 Hansen and Jensen (pp. 19 and 33) refer to the small and peculiar fjord Amituarsuk in the Frederikshaab district, where the cod are enclosed as it were in a trap. The fjord was investigated in 1909 by the "Tjalfe" and again in 1930. The cod in this fjord were unusually thin. In addition to algae the stomachs contained thick-shelled molluscs such as *Leda pernula*, *Mya truncata*, *Littorina* and *Margaritha*. They were found whole in the gut and the cod apparently has difficulty in digesting such food. The cod here were also very greedy and keen to bite at the hook.

The ctenophores *Beroe*, *Bolina*, *Mertensia* and *Pleurobrachia*, which occur very frequently in the plankton nets, often in very great quantities, are often swallowed by the cod, even to gorging. As food they can only be of very small importance owing to their great water content. If they are so often eaten, it is due to the fact, that they are an easy prey owing to their abundance and slow movements; the cod does not pick and choose its food, but swallows all it can get hold of.

Worms, especially various polychaets, such as *Nereis*, *Pectinaria* etc., are of some importance. They are very frequently found in cod from the banks, in the Lichtenau Fjord and the sounds at Cape Farewell. They occur most frequently in stomachs of the large cod, which mostly seek their food at the bottom.

Fig. 15 shows the proportions of the different foods based on the stomach investigations. The analyses from the banks embrace 254 specimens, those from the coast and fjords 1,413. The difference in the composition of the food-stuffs on the banks and in the coastal and fjord areas is clearly seen from the figure. On the banks crabs dominate, then come other Crustacea (*Pandalus*, amphipods and euphausids), fish and worms. In the coastal and fjord areas the Crustacea are dominant, then come fish; *Hyas* and worms are very rare by comparison with the banks. Ctenophores occur frequently. Fig. 15 and Table 19 are however misleading, so far as the fish from the coastal and

fjord areas are concerned, as the samples containing the capelan exclusively, are not included. As a matter of fact, fish (i. e. capelan and lance) constitute the most important of the food-stuffs in this area, even if they are to some degree seasonal.

The food of the cod in the Newfoundland area has been noted by HAROLD THOMPSON (1943). The conditions there are much the same as in Greenland. Fish contribute the main part of the food, especially capelan, lance and herring. The capelan is of extreme importance, particularly for the cod in the coastal area and quite specially in the northern part of the area. In Labrador it can be found in the stomachs as late as in September. THOMPSON writes: "There is no doubt that cod in the region mentioned depend upon caplin for the period of gross feeding and recuperation which succeeds the spawning season".

On the banks the cod also take a quantity of capelan but here the lance, as at Greenland, is the principal food especially near the outer slopes of the banks. In the south-western region especially herring form an important constituent in the diet of the cod; but on the banks and in the south-east region they are seldom seen in the stomachs. Crustaceans, next to fish, are the most common components of the cod's food. Shrimps and prawns are taken throughout the Newfoundland area, but particularly in the more northerly portion.

"In fact one might say that here, just as caplin (inshore) and lance (on the banks) provide for periods of high-feeding, shrimps provide throughout the year the chief subsistence diet." At Newfoundland as on the West Greenland banks *Hyas* is an important component of the cod's food.

As at Greenland molluscs are somewhat less in importance than the above-mentioned foods.

Ctenophores and tunicates are also found in the stomachs of the Newfoundland cod just as in Greenland waters.

MESCHKAT (1936) has investigated the food of the cod at the Westmanna Isles. The proportions of the different components are much the same as at Greenland. Crustacea are the most important, next come fish (capelan and lance). All other forms are of much less importance.

IDELSON (1930) has examined the food of cod in the Barents Sea. Here also the conditions are much the same as at Greenland apart from the herring, which is but rarely taken in the Greenland cod. IDELSON writes: "The principal food of the cod in the Barents Sea consists of fish (herring, capelan (*Mallotus*) and others) and Decapoda Macrura (principally *Pandalus*). Besides this staple food, typical benthos organisms are also frequently found in the stomachs of cod, such as Vermes, Echinodermata, Mollusca, which, however, are quantitatively of very small importance. Moreover, indications exist (see SCHVEINZEW (1, 2) and the reports of the Murman Expedition), that the stomachs of the cod contain sometimes Beroe (Ctenophora) in great quantity."

In most parts of the Barents Sea almost the same food components are found as in the Greenland coastal and fjord areas. On the banks at Cape Kanin, as on the Greenland coastal banks, it is *Hyas* which is the principal food.

V. Races.

Can Numerical Characters be used for the Characterisation of Races of the Cod at Greenland?

In 1930 in his important work on the races of the Atlantic cod SCHMIDT has shown, on the basis of a very large material of number of vertebrae and rays in D_2, that there is a considerable geographical variation in these characters. The lowest values are found in the eastern Atlantic, the highest in the western Atlantic along the American coast. In both regions the number of vertebrae increases from south to north. The number may vary in different years, but not to such an extent as to obscure the geographical differences. SCHMIDT points out, that populations of cod in separate seas and fjords have as a rule a lower number of vertebrae than populations in the coastal and banks areas. In regard to Greenland it appears, that there is a fairly large difference between the populations of this region and those of the American region, the latter having a much higher number of vertebrae on the whole. From which it follows, that there is apparently but little if any connection between these two regions. On the other hand, the cod of Greenland and the cod of Iceland are much more closely related in number of vertebrae. SCHMIDT also refers to the migration of cod from Greenland to Iceland, first observed in 1930.

THOMPSON (1943, pp. 63—69) has supplemented SCHMIDT's investigations and given several enumerations of the number of vertebrae in the cod from different localities at Newfoundland.

At Greenland investigations have continued on the number of vertebrae and rays in D_2 of cod from different localities. Some of these recent enumerations have been dealt with by TÅNING (1938). Still more have been made since then. Enumerations of vertebrae and D_2 rays in cod from localities at Greenland are given in the chart, Fig. 16, and in Table 20. On the chart the figures in brackets indicate the year when the sample was taken. Two samples are omitted however; the one because the material was too small (18 specimens from Godhavn 1932), the other because the material was a mixture of specimens from two localities remote from each other (Lille Hellefiske Bank and Fiskenæs Bank 1930).

For the sake of comparison the table likewise contains some enumerations from American localities, from THOMPSON and SCHMIDT, and from Iceland,

Table 20 A.

Locality	Year	Number of Vertebrae 57	56	55	54	53	52	51	Total	Av.
1. Rodebay, Jbhvn. Dist.	1935	—	2	28	80	32	5	—	147	53·93
2. Godhavn	1935	—	2	15	74	53	8	—	152	53·67
3. Christianshaab	1935	—	2	18	43	32	4	1	100	53·79
4. Ikertok, Holstbg. Dist.	1931	—	2	23	72	24	1	—	122	54·01
5. Sukkertoppen	1924	—	—	6	59	69	5	—	139	53·47
6. Sukkertoppen	1925	—	—	4	60	70	11	—	145	53·39
7. Sukkertoppen	1927	—	4	60	189	86	17	—	356	53·86
8. Lille Hellefiske Bank	1932	—	2	12	65	46	7	—	132	53·67
9. Kangia Fjord, Skt. Dist.	1933	—	—	2	24	62	28	3	119	52·95
10. Angmasivik, Skt. Dist.	1934	—	1	9	57	63	7	—	137	53·52
11. Kobbe Fjord, Gthb. Dist.	1933	—	1	37	102	77	20	2	239	53·65
12. Kapisigdlit, Gthb. Dist.	1933	1	3	14	43	53	20	3	137	53·42
13. Kapisigdlit, Gthb. Dist.	1936	—	—	7	34	74	9	—	124	53·31
14. Fylla Bank	1937	—	1	9	40	40	8	—	98	53·54
15. Dana Bank	1937	—	—	2	32	32	9	—	75	53·36
16. Julianehaab	1928	—	—	7	85	92	16	—	200	53·42
17. Julianehaab	1930	—	—	3	54	126	32	2	217	53·11
18. Lichtenau, Jlhb. Dist.	1929	—	—	9	58	119	35	1	222	53·18
19. Angmagssalik	1926	—	—	—	13	11	1	—	25	53·48
20. Angmagssalik	1927	—	—	—	44	85	27	2	158	53·08
21. Angmagssalik	1930	—	—	—	28	84	32	3	147	52·93
22. Denmark Strait	1931	—	—	4	38	53	9	—	104	53·36

Locality	Year	Number of Rays in D_2 26	25	24	23	22	21	20	19	18	17	16	Total	Av.
1. Rodebay, Jbhvn. Dist.	1935	—	2	3	10	33	31	29	15	5	2	—	130	20·91
2. Godhavn	1935	—	—	5	14	25	38	44	19	5	—	—	150	20·81
3. Christianshaab	1935	1	—	2	9	20	27	23	13	4	1	—	100	20·84
4. Ikertok, Holstbg. Dist.	1931	—	—	—	8	23	28	31	19	10	3	—	122	20·41
5. Sukkertoppen	1924	—	—	1	2	13	30	40	34	10	3	—	133	20·02
6. Sukkertoppen	1925	—	—	—	5	11	31	48	30	22	2	—	149	19·92
7. Sukkertoppen	1927	—	1	26	23	66	78	99	42	19	1	1	356	20·85
8. Lille Hellefiske Bank	1932	—	—	—	—	—	—	—	—	—	—	—	—	—
9. Kangia Fjord, Skt. Dist.	1933	—	—	—	—	5	14	34	40	18	4	2	117	19·38
10. Angmasivik, Skt. Dist.	1934	—	—	1	—	5	17	37	36	27	8	2	133	19·32
11. Kobbe Fjord, Gthb. Dist.	1933	—	1	5	19	37	55	55	13	10	—	1	196	20·80
12. Kapisigdlit, Gthb. Dist.	1933	—	—	1	1	17	34	36	28	13	3	1	134	19·94
13. Kapisigdlit, Gthb. Dist.	1936	—	—	—	3	8	24	37	36	11	3	2	124	19·79
14. Fylla Bank	1937	1	1	—	3	18	27	17	21	6	1	—	95	20·49
15. Dana Bank	1937	—	1	1	3	16	17	16	10	8	1	—	73	20·52
16. Julianehaab	1928	—	—	—	3	17	47	65	48	16	3	—	199	20·01
17. Julianehaab	1930	—	—	2	5	26	54	73	47	7	2	1	217	20·27
18. Lichtenau, Jlhb. Dist.	1929	—	1	3	12	40	44	61	46	14	4	1	226	20·38
19. Angmagssalik	1926	—	—	—	—	1	8	12	3	—	1	—	25	20·16
20. Angmagssalik	1927	—	—	1	1	14	36	61	34	11	4	—	162	20·02
21. Angmagssalik	1930	—	—	1	4	11	42	39	31	17	1	—	146	20·08
22. Denmark Strait	1931	—	—	1	3	8	21	34	24	8	1	1	101	20·03

from SCHMIDT and TÅNING. In the Greenland area 21 samples have been obtained, from 15 localities; six of these with ten samples are from the coastal area, three from the off-shore banks and six with seven samples from the fjords. Some of the samples are of small cod belonging to the age-groups I, II and III taken inshore with the eel-seine, in other cases we have large old cod belonging to several age-groups. In the samples No. 9 and No. 12 the age of the cod has been determined, so that the average value could be ascertained for the different year-classes. At four of the localities samples have been obtained in different years, namely Sukkertoppen (Nos. 5, 6 and 7), Kapisigdlit in Godthaab Fjord (Nos. 12 and 13), Julianehaab (Nos. 16 and 17) and Angmagssalik (Nos. 19, 20 and 21).

It would appear, that fairly large variations may occur in the number of vertebrae from year to year, from the same locality. This can readily be seen from the three samples from Sukkertoppen, the two from Julianehaab and the three samples from Angmagssalik. In samples from East Iceland SCHMIDT found that similar conditions prevailed there also.

In sample No. 12, which consists of spawning cod

Table 20 B.

Locality	Number of Vertebrae 57	56	55	54	53	52	51	Total	Av.
St. John's	5	13	24	17	6	—	—	65	54·91
Flover Cove, St. Barbe Isl.	11	50	52	14	—	—	—	127	55·46
Labrador	10	19	22	7	6	—	—	64	55·31
Selvogsbanki[1])	—	—	—	53	118	24	—	195	53·14
Djupallsrif	—	—	—	23	69	28	—	120	52·96
Isafjord	—	—	—	6	82	59	2	149	52·62
Faxa Bay	—	—	—	5	69	131	16	221	52·29
Off Landeyasandur	—	—	—	11	46	27	1	85	52·79
Ingolfshófdi	—	—	—	22	82	30	—	134	52·94
Off Horna Fjord	—	—	3	63	231	80	3	380	52·96

Locality	Number of Rays in D_2 25	24	23	22	21	20	19	18	17	16	Total	Av.
St. John's	1	—	3	11	17	20	9	6	—	—	67	20·48
Flover Cove, St. Barbe Isl.	1	3	11	30	33	29	18	5	1	—	131	20·86
Labrador	—	1	4	8	20	16	14	2	—	—	65	20·52
Selvogsbanki[1])	—	—	1	15	35	53	47	16	3	1	171	19·85
Djupallsrif	—	1	2	2	28	45	32	12	4	—	126	19·79
Isafjord	—	—	1	3	16	44	47	27	12	1	151	19·23
Faxa Bay	—	—	1	11	31	71	56	38	10	—	218	19·51
Off Landeyasandur	—	—	1	8	16	27	21	10	2	—	85	19·86
Ingolfshófdi	—	—	—	6	14	35	43	29	5	1	133	19·29
Off Horna Fjord	—	—	1	27	58	119	101	47	13	2	368	19·65

[1]) 1934.

from Kapisigdlit in Godthaab Fjord, the age of the cod was determined by means of the otoliths.

Table 21. Age and Number of Vertebrae of Cod from Kapisigdlit.

Age-Group	Year-Class	Nos.	No. of Vertebrae
VII	1926	50	53·24
IX	1924	20	53·30
XI	1922	30	53·21
XVI	1917	37	53·76
Total ...		137	53·42

It will be seen, that the 1917 year-class has a higher average value for the number of vertebrae than the other years, in which the averages are much the same.

Schmidt divided the different cod populations into four groups according to the number of vertebrae and gave a chart to illustrate the divisions. The different populations in the Atlantic region can be arranged roughly as below (Table 22).

With regard to the number of fin-rays in D_2 Schmidt also divides the populations into four groups roughly as in Table 23.

In number of vertebrae the Greenland cod belong to Group II which also contains the cod populations of U.S.A., Iceland, Norway and the eastern Baltic, but in number of fin-rays in D_2 the Greenland cod belong to Group I along with the cod from Labrador and Newfoundland.

In his experiments with sea-trout Tåning has shown (1946), that the number of vertebrae is fixed at a very early stage in the development of the egg. Similar experiments have not hitherto been made on the cod, the fry of this species being difficult to rear in aquaria up to such a size that the number of vertebrae can be counted, but presumably the same condition holds good. The number of fin-rays is certainly fixed at a much later stage of development.

Table 22. Grouping of the Atlantic Cod according to Number of Vertebrae.

Group	I	II	III	IV
No. of Vertebrae	54·00—55·46	52·41—53·99	52—52·10	51·47—51·99
	Labrador and Newfoundland	U.S.A. coast	Faroes	Waters N. of British Isles
		Greenland	North Sea	
		Iceland	Kattegat and Belt Sea	
		Norway	West Baltic	
		East. Baltic		

53.67-20.81(35)
Godhavn
53.93-20.91(35)
53.79-20.84(35)
Egedesminde
54.01-20.41(31)
Holstensborg
53.47-20.02(24)
53.39-19.92(25)
53.86-20.85(27)
Sukkertoppen
52.95-19.38(33)
53.67-20.20(32)
53.52-19.32(34)
53.42-19.94(33)
53.31-19.79(36)
Godthaab
53.54-20.49(37)
53.65-20.80(33)
53.36-20.32(37)
Arsuk
53.42-20.01(28)
Julianehaab
53.11-20.27(30)
53.18-20.38(29)
Nanortalik
K. Farvel (Umanarsuaĺ)
53.48-20.16(26)
53.08-20.12(27)
52.93-20.08(30)
DISKO
DAVIS STRAEDE
PIKIUTOLEK
UMEVIK
IGDLOLUARSUK
AKORNARMIUT
UMANAK
TINGMIARMIUT
IKERMIUT
PUISORTOK
ANORETOK
AUARKAT
ILIVILIK
KANGERDLUGSUATSIAK
IKERASARSUAK
INIGSALIK
ANGMAGSALIK
KIALINEK
Fiskernæs
Frederikshaab
Fredrikshaab
Nunarsuit
Mt. Forel
Inglefield Land
Leifs ö
Tasiusak
Ikerasak
Tasiussak
Kangamiut
Umanarsuk
Fiskefjord
Godthaabsfjord
Nordfjord
Mellemfjord
Jacobshavn
Claushavn
Godhavnsbugt
Holsteinsborg
Sukkertoppen Isblink
Fiskernæs Isblink
Frederikshaab Isblink
Julianehaab Bay
Tunugdliarfik
Tasermiut Fjord
Tasermiut
Nunatak
Nualik
Aggas ö
Aputitek
Mt. Forel
Inglefield Land
Steenstrup Brær
Leifs ö
Tasiusak
Ikerasak
Tasiussak
Tasermiut
Tunugdliarfik
Tasermiut Fjord
Nunatak
Fr. Christian Sund
Eggers ö
Østgrønland
Frederikshaab
Julianehaab
Nanortalik
Arsuk
Fiskernæs
Fredrikshaab
Godthaab
Sukkertoppen
Holsteinsborg
Egedesminde
Claushavn
Jacobshavn
Godhavn
Disko
Nordfjord
Mellemfjord
Fiskefjord
Kangamiut
Umanarsuk
Sukkertoppen Isblink
Holsteinsborg
Egedesminde
Claushavn
Jacobshavn
Godhavn
Disko
Nordfjord
Mellemfjord
Fiskefjord
Kangamiut
Umanarsuk
Godthaabsfjord
Fiskernæs Isblink
Frederikshaab Isblink
Julianehaab Bay
Tunugdliarfik
Tasermiut Fjord
Tasermiut
Nunatak
Nualik
Aggas ö
Aputitek
Mt. Forel
Inglefield Land
Steenstrup Brær
Leifs ö
Tasiusak
Ikerasak
Tasiuss

Table 23. Grouping according to Number of Rays in D_2.

Group	I	II	III	IV
Rays in D_2	> 20	19·0—19·9	18—18·9	< 18
	Labrador and Newfoundland	U.S.A. coast	Waters W. of British Isles	East. Baltic
	Greenland	Iceland	S. North Sea	
		Faroes	Kattegat and Belt Sea	
		N. North Sea	W. North Sea	

TÅNING has likewise shown in his sea-trout experiments, that even small changes in temperature may cause fairly large variations in the number of vertebrae. From this it may be concluded, that the temperature in the sea and possibly also the salinity and other factors may influence both the number of vertebrae and number of fin-rays. These characters thus seem to be determined phenotypically to some extent and consequently of less value in the consideration of racial characters, at least in the case of a restricted sea area such as the Greenland waters.

That the cod stocks of Greenland and Iceland resemble each other in regard to number of vertebrae is only natural, as the investigations have shown, that the stocks of these two areas are closely connected with each other. From marking experiments we know that the cod both from East and West Greenland migrate over to Icelandic waters to spawn in the spring, and we also know that after spawning many in search of food migrate to West Greenland. Further, the investigations of the "Dana" in the Denmark Strait have shown, that at any rate in certain years there is a drift of the cod fry from Iceland over to Greenland. The number of vertebrae, which as mentioned is determined at a very early stage in development, may be considered to have been already fixed whilst the fry are in the neighbourhood of the spawning grounds at Iceland, in fairly warm water. The number of vertebrae should thus be the same as in the cod which remain in Icelandic waters.

On the other hand, the number of fin-rays is only fixed later when the fry have come under different hydrographical conditions with somewhat lower temperatures, on the way to the waters of Greenland. The effect of the lower temperatures is to produce a higher number of fin-rays in D_2. This perhaps explains why the Greenland cod come to be grouped with the Labrador and Newfoundland populations with regard to number of fin-rays; in these the fry during development are affected by the fairly low temperatures of the cold Labrador current.

With regard to regional differences we see that, apart from the fjord populations, the average values for the number of vertebrae and in part also for the fin-rays in D_2 are highest in the northern parts of the West Greenland waters, i. e., from Godthaab northwards; thus higher than in the districts of Julianehaab and Angmagssalik, though the differences are not great. The fluctuations of the averages are shown in the following table.

Table 24. Number of Vertebrae and Fin-Rays in D_2 in Cod from different parts of Greenland.

	N.-West Greenland	S.-West Greenland	Angmagssalik
No. Vertebrae ..	53·39—53·93	53·11—53·42	52·93—53·48
No. Fin-Rays in D_2	19·92—20·91	20·01—20·52	20·02—20·16

SCHMIDT has shown for several species of fish, that the average value for the number of vertebrae is higher in the case of open-sea populations than in the fjord populations. This rule appears to hold good for viviparous species as for those with demersal and pelagic eggs. As examples SCHMIDT mentions the viviparous blenny, herring and cod. From West Greenland we have material from five different fjords and we may now investigate, whether the condition described by SCHMIDT also holds good here.

The material available comes from Ikertok Fjord in the Holsteinsborg district, Kangia Fjord and Angmasivik Fjord in the Sukkertoppen district and the Godthaab and Kobbe Fjords in the Godthaab district. The last-mentioned however may be omitted from consideration, as it is quite a small fjord.

From Ikertok a sample from 1931 shows the highest value for number of vertebrae in the cod of Greenland, namely 54·01. This seems to be opposed to the rule laid down by SCHMIDT. As mentioned elsewhere in this work, Ikertok has its own special population, remarkable among other things for its slow growth. In the spawning time in spring it is caught by the Greenlanders through holes in the ice. The great cod fishery which is carried on a little later, is based on cod which have migrated into the fjord from outside. The material used here for number of vertebrae consists of small cod, presumably of the II-group, from the inner part of the fjord and thus may be considered to belong to the fjord's own stock.

In the Kangia Fjord we find very low average values for the number of vertebrae and D_2 fin-rays, namely 52·95 and 19·38. These values are much lower than those in the samples from the adjacent Sukkertoppen and Lille Hellefiske Bank (samples Nos. 5, 6, 7 and 8). The Kangia stock thus follows the rule, that fjord stocks have a smaller number of vertebrae and fin-

rays than the open-sea populations. The cod in Kangia Fjord are markedly different in appearance from the cod met with out on the coast and banks, being plumper with the colour of the belly darker. They remind one constantly of *Gadus ogac.*

In the Angmasivik Fjord in the Sukkertoppen district 53·52 was found for the number of vertebrae in 1932, thus a fairly high average not below what is found in the cod of the coastal region and banks. On the other hand, the number of fin-rays in D_2 was low as in Kangia Fjord, namely 19·32, the lowest for cod at Greenland. There are no outer characters as in Kangia to distinguish the Angmasivik cod from the coastal and banks cod.

From the Godthaab Fjord we have enumerations of vertebrae and fin-rays from 1933 and 1936. The 1933 sample consists of spawning cod and contains four year-classes (see Table 21, p. 45), whilst the 1936 sample is made up of the I-group, year-class 1935. As mentioned previously, the year-class 1917 is represented by 37 specimens in the 1933 sample, and this year-class had a higher average for number of vertebrae than the other three year-classes, in which the average was much the same. Excluding the 1917 class the average of the sample is 53·42, which is very close to the average 53·31 found in 1936. Compared with the values found in adjacent localities outside the fjord (samples Nos. 11 and 14) the averages are certainly somewhat lower in the fjord, but the difference is not striking. The average for the number of fin-rays in D_2 is also lower, below 20 in both samples, than what is found in the near-by coastal waters and on the banks.

Thus, the cod population of the Godthaab Fjord follows the rule laid down by SCHMIDT, but the differences between the populations inside and outside the fjord are but faint by comparison with the population in Kangia. That the Godthaab Fjord has its own population is seen more clearly from an investigation of the otoliths. In by far the most cases these differ completely from what is found in the cod of the coast and banks. A cross-section of the otolith in cod from the Godthaab Fjord has almost the same appearance as the otolith of the Norwegian coastal cod (ROLLEFSEN 1932). The winter-rings are not prominent and many secondary rings are present.

The differences in the numerical characters mentioned are on the whole very small in samples of cod from various places at Greenland, with the one exception of the isolated Kangia population. The differences observed in the number of vertebrae in the various year-classes are sometimes just as great or greater than those found between samples from localities remote from each other. The uniformity in the average values presumably comes from the fact, that the cod fry may be carried for long distances by the currents and the stock becomes a mixed population from different spawning places. From the spawning grounds on the banks and at the coast the fry are carried northwards by the north-going current, and some of the fry from spawning grounds in the fjords are carried into the coastal area by the strong outgoing current. In this way a great mixing of the populations takes place. In addition, the larger cod migrate to some extent from one locality to another. This migration affects mostly the cod of the banks, in lesser degree the fjord cod. Marking experiments in the northern and middlemost parts of the West Greenland waters (zones I—VII) have shown, that among the recaptures of cod marked on the banks, coast and in the fjords respectively ca. 75, 63 and 24 per cent. have migrated to other zones or to Iceland. It is evident that such a mixing partly of fry and partly of larger cod must lead to uniformity in such characters as those discussed here. Only in the case of a fjord population which is isolated and without connection with other areas, can we expect to find racial characters differing from those at other localities. The only locality of this kind so far discovered is Kangia, a small fjord with a number of islands off its mouth, which to a certain extent cut it off from the outer area. It is possible nevertheless, that one may also find other places with similar isolated populations and possessing distinct racial characters.

The marking experiments offer a considerably better means than the numerical characters for the investigation of the mutual relationships between the cod populations and possible occurrence of local groups. These have shown with much clearer evidence (see pp. 49—61), that the Greenland stock of cod is closely connected with the Icelandic, but not with the populations at Newfoundland. In the case of the fjords the marking experiments in Kangia have shown this to contain a special population. Of 77 cod marked in Kangia in 1933 seven (ca. 9·1 %) have been recovered; three were retaken in Kangia, two in the neighbourhood at Napassok and two at Atangmik only about 30—35 miles from the place of marking.

The results of the marking experiments in Ikertok and the Godthaab Fjord are shown in Table 27 and on the charts, Figs. 18 and 21, in the section on migrations. In Ikertok 442 cod were marked and in Godthaab Fjord 1080. A very large number of the recaptures in these experiments came from the neighbourhood of the marking places, namely 61 in Ikertok and 106 in Godthaab Fjord (75·3 % and 76·3 % respectively of the recaptures). But few cod from these experiments were recaptured at Iceland, namely 2 and 9 respectively (2·5 % and 6·5 % of the recaptures).

The many recaptures near the place of marking in these fjords show, that the cod here are more or less stationary and that each fjord has its own population. This conclusion is further strengthened by the fact, that spawning takes place in the fjords and also by the fact, that the rate of growth is less than in the cod of the coastal area and on the banks.

VI. Migrations and Fluctuations.

A. Migrations.

1. Survey of the Marking Experiments.

Cod marking experiments in Greenland waters have been carried out in the years 1924 to 1939. In 1940 the war put a stop to this work which was only taken up again in 1946 and continued in 1947 and 1948. The experiments were directed by the Greenland Administration in collaboration with "Kommissionen for Danmarks Fiskeri- og Havundersøgelser".

In an earlier publication (HANSEN, JENSEN and TÅNING 1935) the results are given of the experiments in 1924—33. TÅNING in various papers (1934, 1937) has also mentioned the Greenland experiments and brief references have been made to them in several of the present author's annual reports (Beret. og Kund. vdr. Grl. St.).

As the results of the marking experiments from 1934—39 will be dealt with in a future publication, in which the experiments of the separate years will be treated in the same detailed way as in the 1935 publication, only a brief survey will be given here of what we have learnt about the migrations of the Greenland cod.

The experiments were carried out at many localities along West Greenland from Cape Farewell, ca. 60° N., to Nugssuak ca. 70°45′N., both on the banks in Davis Strait and in the coastal and fjord areas. Up to and including 1939 altogether 12,801 cod were marked at West Greenland and 772 at East Greenland in the Angmagssalik district. Of the 12,801 marked at West Greenland 1067 have been recaptured up to the end of 1946, giving a recovery of 8·3 %; 616 cod were recaptured in Greenland waters, whilst 449 were retaken at Iceland. One was recaptured at the Faroes and one in the Barents Sea. Practically all the cod marked had a total length of over 50 cm.

Table 26 gives a summary of the numbers of cod marked in the different years and the distribution of the recoveries at Greenland and Iceland in the various years. It shows among other things that the percentage recaptured has varied greatly in the different experiments. The smallest percentage is from the 1926 experiment, 2·6 %, whilst the highest, 13·1 %, is from 1937. The percentage of recoveries lies over 5 in all the experiments except in the years 1924, 1926 and 1928.

For the sake of comparison the same divisions in 9

Table 25. Number of Cod marked at West Greenland in the Different Years.

Zone		Year of Marking															
		1924	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
I	C	—	—	—	—	—	—	—	—	—	—	—	447	456	—	—	—
II	B	—	—	—	—	—	—	—	13	20	—	—	—	42	—	—	—
	C	—	—	—	—	—	—	—	25	—	—	—	—	—	—	—	—
III	B	—	—	26	—	—	—	—	132	399	—	178	—	300	—	298	—
	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	F	—	—	—	80	—	—	—	159	—	—	200	—	—	—	—	3
IV	B	—	—	—	—	—	—	—	465	177	—	224	—	—	17	—	—
	C	282	119	—	—	—	—	4	310	—	—	2	—	—	91	—	—
	F	—	—	50	—	—	—	—	48	—	—	—	—	—	1	—	—
V	B	—	51	—	—	106	—	—	—	—	17	—	172	—	200	—	—
	C	—	—	4	—	—	—	—	—	—	73	—	—	—	—	—	—
	F	—	—	46	—	—	—	—	—	—	77	35	—	—	—	—	—
VI	F	—	—	131	26	—	—	100	47	41	—	1	106	158	239	123	108
VII	B	8	240	83	—	—	—	—	86	—	133	—	10	—	100	—	—
	C	124	—	—	—	—	—	197	182	—	100	81	—	—	1	—	162
	F	—	—	2	—	—	—	—	—	—	—	—	—	—	—	26	—
VIII	B	—	—	—	—	—	—	—	1	—	—	—	—	—	89	—	—
	C	—	—	—	95	—	—	153	—	—	100	—	—	—	—	7	—
	F	—	—	—	—	—	—	200	—	—	125	—	—	—	—	15	37
IX	B	—	—	—	—	3	—	—	—	—	—	—	—	—	—	—	—
	C	—	—	—	—	—	311	428	105	198	—	233	—	—	476	571	551
	F	—	—	—	—	—	189	372	79	269	—	—	—	—	134	96	—
Total ...		414	410	342	201	109	500	1454	1652	1104	625	954	735	956	1348	1136	861

Table 26. Number of Marked Cod recaptured at Greenland (Gr.) and Iceland (Ic.) in the Different Years.

(The horizontal lines give year of marking, vertical lines consecutive years of recapture, the serrated lines connecting the same calendar year.)

No. marked	Total recovered in a year Gr.	Total recovered in a year Ic.	Year of marking	Year of Recapture: 1st Gr.	1st Ic.	2nd Gr.	2nd Ic.	3rd Gr.	3rd Ic.	4th Gr.	4th Ic.	5th Gr.	5th Ic.	6th Gr.	6th Ic.	7th Gr.	7th Ic.	8th Gr.	8th Ic.	9th Gr.	9th Ic.	10th Gr.	10th Ic.	11th Gr.	11th Ic.	12th Gr.	12th Ic.	14th Gr.	14th Ic.	15th Gr.	15th Ic.
414	1	—	1924	1	—	—	—	4	—	5	1	1	—	2	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
410	15	—	1925	15	—	11	—	2	—	2	—	3	—	3	—	3	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
342	16	—	1926	1	—	3	—	—	—	—	—	1	1	1	1	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
201	16	1	1927	6	—	3	—	—	—	2	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
109	6	—	1928	—	—	—	—	—	1	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
500	9	—	1929	4	—	4	5	2	8	5	3	—	2	1	1	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1454	16	7	1930	6	—	11	35	7	16	4	14	5	11	—	7	—	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—
1652	32	47	1931	14	—	23	15	11	21	11	5	4	3	3	3	4	—	1	—	—	—	1	—	1	—	1	—	—	—	1	—
1104	43	35	1932	7	—	5	20	4	20	8	9	4	2	3	1	1	2[1]	—	—	—	—	—	—	—	—	—	—	—	—	—	—
625	22	57	1933	1	—	5	18	8	4	2	1	2	—	3	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
954	48	55	1934	21	—	30	20	21	6	11	1	3	3	5	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
735	58	45	1935	7	—	13	—	12	2	12	—	8	2	2	—	2	—	2	—	1	—	—	—	—	—	—	—	—	—	—	—
956	44	13	1936	1	—	8	—	9	2	13	2	2	—	3	—	1	—	5	—	4	—	1	—	—	—	—	—	—	—	—	—
1348	50	5	1937	9	—	14	35[2]	21	36	12	10	9	13	2	2	—	7	3	—	2	—	1	—	—	—	—	—	—	—	—	—
1136	47	42[1][2]	1938	3	—	16	24	15	6	6	15	12	3	—	3	2	4	1	—	—	—	—	—	—	—	—	—	—	—	—	—
861	64	66	1939	1	—	15	—	4	6	12	3	2	3	2	2	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
12801				64	66	47	16	25	34	30	8	8	13	12	6	5	1	1	—												
Year of Marking				1939		1940		1941		1942		1943		1944		1945		1946													

Total Recoveries.

Year of Marking	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	Total
Greenland.....	14	41	7	12	—	16	36	75	32	22	91	59	47	73	55	36	61
Iceland.....	2	—	2	—	4	21	85	47	54	23	32	4	4	103	55[1][2]	15	451
Greenland + Iceland .	16	41	9	12	4	37	121	122	86	45	123	63	51	176	110[1][2]	51	1067
%.....	3·9	10·0	2·6	6·0	3·7	7·4	8·3	7·4	7·8	7·2	13·0	8·6	5·3	13·1	9·7	5·9	8·3

[1]) Including one recapture from the Barents Sea.
[2]) — - — — - Faroe Islands.

zones has been used as in the section on the distribution of the cod fry. A summary of the numbers of cod marked in these zones is given in Table 25 for the various years.

2. Recoveries at Greenland.

Table 27 A and B gives a complete survey of the recaptures in the different zones of West Greenland. It indicates how many cod were marked in the different zones, on the banks (B), at the coast (C) and in the fjords (F); also in what zones and areas (B, C, F and Iceland) the recaptures were made. From these we gain some idea of the directions the migration takes. Further, the table shows the numbers of stationary cod and of the cod which have migrated northwards or southwards from the various zones.

The less extensive wanderings within the same zone, between banks, coast and fjord, can also be seen from the table. The period from marking to recovery is not indicated.

The number of cod marked in the different zones varies a good deal. The fewest were marked in zone II, in all 100, by far the most in zone IX 4,016. It had been noticed, that a great many of the cod marked in this zone made their way to Iceland, and this induced us to mark an extra large number there.

The percentage of recaptures varies greatly for the different zones. The smallest is for the cod marked on the banks in zone II and in the fjords in zone IV, namely 3 %; the largest, 18·3 %, is from the fjord area in zone III (Amerdlok—Ikertok Fjord). In four areas we find over 10 % recaptures, in III F, V C, VI F and IX C. The percentage recaptured is naturally dependent in great part on the intensity of the fishing in the area, a large fishery giving a better chance for many recaptures. In the two cases where many recoveries have been made, III F and VI F (Amerdlok—Ikertok Fjord and the Godthaab Fjord), we have just the places where an intensive fishery is carried on in a fairly small area and where, in any case, there may be in part local stocks. It will be noticed also in the table, that many stationary cod occur in the two fjords, respectively 61 and 106 or 75·3 % and 76·3 % of all recaptures.

In zone V C we have also in the main local stocks. The cod here were marked at Napassok and Atangmik in the Sukkertoppen district and here also most were retaken near the place of marking, namely, 10 out of 11 recaptures. In zone IX C there are certainly

Table 27 A. **Recaptures of Cod marked in the Different Zones.**

No. of marked	Marked in zone		I B	I C	I F	II B	II C	II F	III B	III C	III F	IV B	IV C	IV F	V B	V C	V F	VI F	VII B	VII C	VII F	VIII B	VIII C	VIII F	IX B	IX C	IX F	Iceland
903	I	C	—	**27**	—	3	1	—	—	—	—	—	1	—	2		—	1										4
67	II	B	—	—	—	**2**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
33		C	—	1	—	—	**1**	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
—		F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1333	III	B	—	2	—	6	—	—	**16**	6	4	2	2	—	1	1	—	—	1	—	1	—	—	—	—	—	1	16
—		C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
442		F	—	1	—	2	—	—	5	5	**61**	—	3	—	2	—	—	—	—	—	—	—	—	—	—	—	—	2
883	IV	B	—	—	—	7	—	—	3	2	1	**18**	5	—	4	—	—	—	2	—	—	—	—	—	—	—	1	23
808		C	—	—	—	2	—	—	1	1	—	1	**23**	—	1	8	—	—	1	—	—	—	—	—	—	—	1	13
99		F	—	—	—	—	—	—	—	—	—	—	1	**2**	—	—	—	—	—	—	—	—	—	—	—	—	—	—
546	V	B	—	1	—	1	1	—	2	2	—	2	2	—	**3**	2	—	—	1	—	—	—	—	—	—	—	1	15
77		C	—	—	—	—	—	—	—	—	—	—	—	—	—	**10**	—	1	—	—	—	—	—	—	—	—	—	—
158		F	—	—	—	—	—	—	—	—	—	—	—	—	—	1	**13**	—	—	—	—	—	—	—	—	—	—	—
1080	VI	F	—	—	—	3	1	—	—	1	—	1	2	—	2	1	—	**106**	4	9	—	—	—	—	—	—	—	9
660	VII	B	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—	**31**	—	—	—	1	—	—	—	—	8
846		C	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	6	—	**10**	—	—	1	—	—	1	—	21
28		F	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	**1**	—	—	—	—	—	—	—
90	VIII	B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	5
355		C	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	—	—	1	—	—	**1**	—	—	1	—	14
377		F	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	1	1	—	—	**2**	—	1	—	17
3	IX	B	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2873		C	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	3	—	—	**81**	12	230[1]
1140		F	—	1	—	—	—	—	—	—	—	2	—	—	—	—	—	1	—	—	—	—	1	—	—	9	**16**	73[2]
	Iceland		—	—	—	7	—	—	5	—	—	1	—	1	1	1	—	—	—	—	—	—	—	1	—	—	2	—

Table 27 B.

No. of marked	Marked in zone		Stationary	Migrated North B	Migrated North C	Migrated North F	Migrated South B	Migrated South C	Migrated South F	Total recaptured No. Gr.	Total recaptured No. Ic.	Total recaptured % Gr.	Total recaptured % Ic.	Percentage recaptured Gr.+Ic.	Percentage recaptured Gr.	Percentage recaptured Ic.
903	I	C	27	—	—	—	5	2	1	35	4	89·7	10·3	4·3	3·9	0·4
67	II	B	2	—	—	—	—	—	—	2	—	100·0	0·0	3·0		
33		C	1	—	1	—	—	—	—	2	1	66·6	33·4	9·1	4·0	1·0
—		F	—	—	—	—	—	—	—	—	—	—	—	—		
1333	III	B	10	8	8	3	8	3	3	43	16	72·9	27·1	4·4		
—		C	—	—	—	—	—	—	—	—	—	—	—	—	6·9	1·0
442		F	61	2	3	—	7	5	1	79	2	97·5	2·5	18·3		
883	IV	B	16	11	2	1	7	5	1	43	23	65·2	34·8	7·5		
808		C	7	4	12	—	2	13	1	39	13	75·0	25·0	6·4	4·7	2·0
99		F	2	—	1	—	—	—	—	3	—	100·0	0·0	3·0		
546	V	B	1	5	8	1	2	—	1	18	15	54·5	45·5	6·0		
77		C	10	—	—	—	—	—	1	11	—	100·0	0·0	14·3	5·5	1·9
158		F	12	—	—	—	—	1	1	14	—	100·0	0·0	8·9		
1080	VI	F	106	6	5	—	4	9	—	130	9	93·5	6·5	12·9	12·0	0·8
660	VII	B	22	4	5	—	4	1	—	36	8	81·8	18·2	6·7		
846		C	8	—	1	6	—	4	—	19	21	47·5	52·5	4·7	3·7	1·9
28		F	1	—	—	—	—	—	—	1	—	100·0	0·0	3·6		
90	VIII	B	—	—	—	—	—	2	—	2	5	28·6	71·4	7·8		
355		C	—	1	3	—	—	1	—	5	14	26·3	73·7	5·4	1·6	4·4
377		F	1	—	2	1	—	1	1	6	17	26·1	73·9	6·1		
3	IX	B	—	—	—	—	—	—	—	—	—	—	—	0·0		
2873		C	47	2	26	4	—	12	7	98	230[1]	29·8	70·2	11·4	3·2	7·5
1140		F	11	2	4	5	—	4	4	30	73[2]	29·1	70·9	9·0		
		Total ...	345	45	81	21	39	63	22	616	451[3]	57·7	42·3	8·3	4·8	3·5

[1]) Including one recaptured in the Barents Sea.
[2]) — - — at the Faroe Islands.
[3]) — - — in the Barents Sea and one at the Faroe Islands.

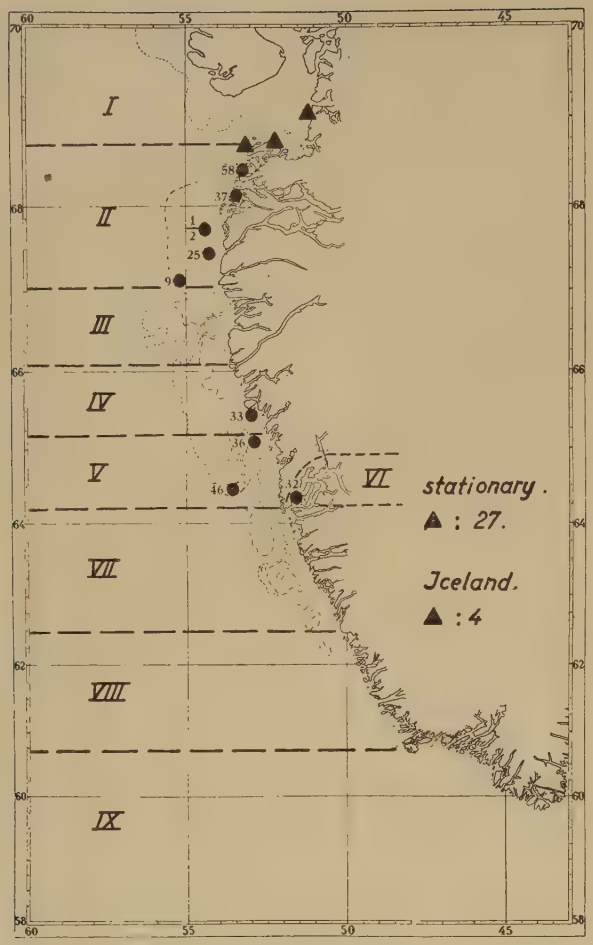

Fig. 17. Recoveries of Cod taken outside the zones where they were marked.

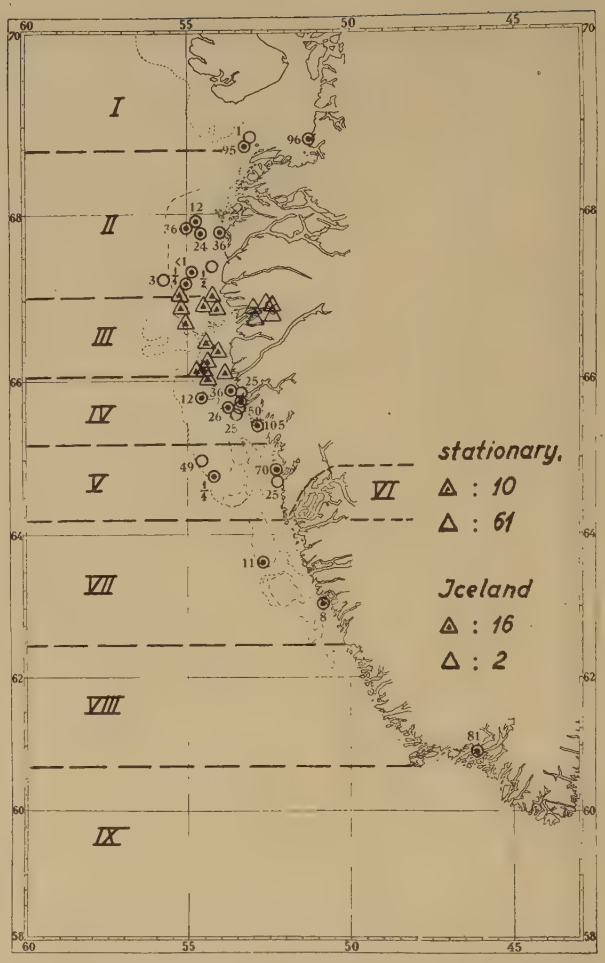

Fig. 18. Recoveries of Cod taken outside the zones where they were marked.

many recaptures of stationary cod, the third largest number, but in relation to the large number of recaptures altogether of cod marked in this zone, it is not specially large, just 14·3 % of all the recaptures. For this zone the recaptures at Iceland number most, 230 or 70·2 % of the recaptures.

a. Stationary Cod.

The number of stationary cod, meaning those recaptured in the same area (banks, coast, fjords) and zone in which they were marked and at a distance less than 20 nautical miles from the marking place, has been 345 in all. Of these 51 were from the banks, 100 from the coast and 194 from the fjords. In proportion to the numbers marked in these areas we have in percentages: banks 1·4, coast 1·7 and the fjords 5·8. Considerably more stationary cod have thus been in the fjords than in the other two areas; this was to be expected, as some of the fjords at any rate contain local populations. Excluding the recaptures at Iceland we see from the table, that most of the recaptures were made in the same zone as where the fish were marked. This stationary tendency is certainly due in part to the fact, that many of the cod marked have not been mature and have thus had no inclination to migrate. Further, it has been noticed, that very large cod do not show the same tendency to undertake long migrations as the younger medium-sized cod (v. Hansen, Jensen and Tåning 1935, p. 81).

b. North and South Migrations.

In West Greenland waters 147 cod have been recaptured north of the localities where they were marked and 124 to the south. The charts, Figs. 17—24, indicate the Greenland localities where the cod marked in the various zones were recaptured. They do not include the individuals recaptured in the same zone as they were marked. The principal marking localities are represented by triangles; white triangles for the fjords, black for the coastal waters, whilst the

Fig. 19. Recoveries of Cod taken outside the zones where they were marked.

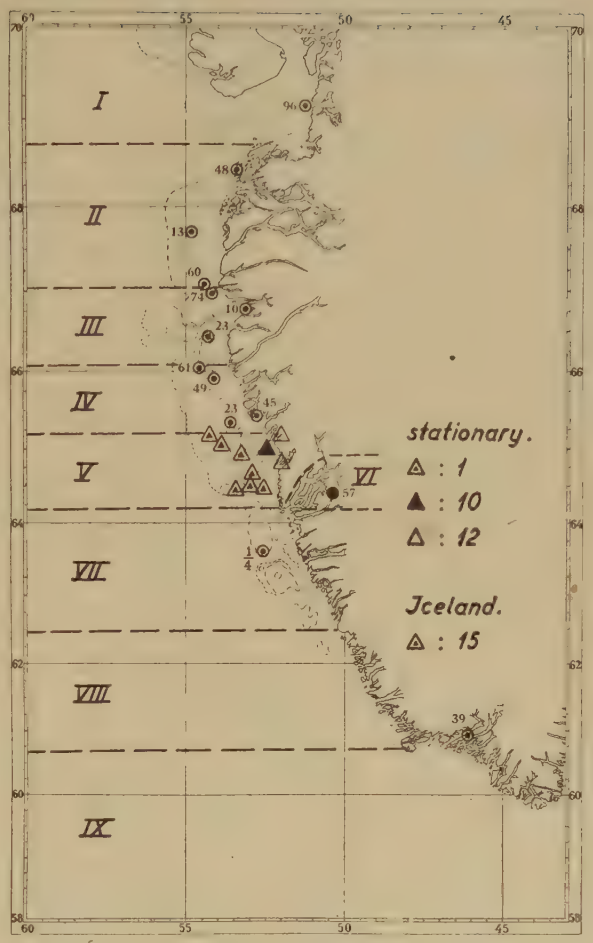

Fig. 20. Recoveries of Cod taken outside the zones where they were marked.

marking places on the banks are indicated by white triangles enclosing a small black triangle. As the localities are very numerous and often very close to each other, only the principal ones have been noted in the charts. The localities of recaptures are noted by circles; the open circles indicating the cod marked in fjords, the black those marked in the coastal waters and the clear circles with a black spot the cod marked on the banks. The figures alongside the symbols indicate how many months have passed between marking and recapture.

Excluding the recaptures in the marking zone itself, where they have been most numerous, as mentioned above, we see from the charts as from Table 27, that most of the recaptures have been made in the zones lying nearest that in which the marking has

Table 28. Number of Recaptures from Markings on Off-Shore Banks, in Coastal Waters and in Fjords.

A includes the cod retaken near the marking place, *B* excludes these stationary cod.

Total liberated		Off-Shore Banks 3,582			Coastal Waters 5,895			Fjords 3,324			Total 12,801
		A		B	A		B	A		B	A
		n	%	n	n	%	n	n	%	n	n
Recaptured at Greenland	Off-Shore Banks..	**101**	70·1	**50**	14	6·7	14	21	8·0	21	136
	Coastal Waters ...	33	22·9	33	**175**	83·7	**75**	35	13·3	35	243
	Fjords.....	10	7·0	10	20	9·6	20	**207**	78·7	**13**	237

Fig. 21. Recoveries of Cod taken outside the zones where they were marked.

Fig. 22. Recoveries of Cod taken outside the zones where they were marked.

taken place; the numbers decreasing as a rule the farther we go from the marking zone. Speaking relatively many cod marked in other zones have been recaptured on the Lille and Store Hellefiske Banks, but relatively few from the Julianehaab and Frederikshaab districts. The extensive fishery by foreign boats on the Hellefiske Banks accounts in great part for the relatively many recaptures from there.

Table 28 gives a summary of the numbers of cod marked in the different areas (banks, coast, fjords) and the numbers recaptured in these areas. It will be seen that of the cod marked on the banks, most were retaken on the banks, most in the coastal waters of cod marked in the coastal area and likewise most recaptures in the fjords of cod marked in the fjords.

It will be seen from Table 28, that of the cod marked in the fjords most were retaken in the coastal waters, not quite so many on the banks and but few in other fjords.

The recaptures at Greenland do not show any marked tendency on the part of the cod to migrate to this or that area, as would be the case, for example, if the cod collected together on special spawning grounds.

3. Recoveries at Iceland.

The great spawning migrations of the cod to Iceland, a phenomenon of the greatest importance for the Greenland fishery, take place mainly from the southern zones. For the zones VIII and IX, the Frederikshaab and Julianehaab districts, over 70 % of the recaptures came from Icelandic waters. For the coastal area in zone VII the recaptures at Iceland are also numerous, over 50 %. From the marking experiments in the northern districts the percentage of recaptures at Iceland is very low; for the two northern zones I and II together 11·4 % of all recaptures came from Iceland. For the more southerly zones the recap-

Fig. 23. Recoveries of Cod taken outside the zones where they were marked.

Fig. 24. Recoveries of Cod taken outside the zones where they were marked.

tures at Iceland show the following percentages: zone III, 12·9; zone IV, 21·8; zone V, 25·9; zone VI, 6·5; zone VII, 34·1; zone VIII, 73·5; zone IX, 70·3. The percentage of Icelandic recaptures thus increases steadily the farther south we go.

The low percentage of recaptures from Iceland for zone VI is due to the fact, that this zone only embraces the Godthaab Fjord, which possibly in part has its own local population.

The two last columns in Table 27 show what percentage of the marked cod was retaken at Greenland and Iceland respectively. Excluding the zones III and VI, which embrace fjords where the fishery is intensive and the recaptures therefore high, the percentages for the recaptures at Greenland are fairly uniform for the northern zones, 3·9 % to 5·5 %, but low for the two southern districts, 1·6 % and 3·2 %. The reverse is the case for the recaptures at Iceland, low but rising slightly southwards for the northern zones, from 0·4 to 2·0 %, and high for the two southern zones, 4·4 and 7·5 %.

The emigration to Iceland from the northern districts is thus comparatively small. Egedesminde is the most northerly district from which emigration has taken place. There have been no recaptures from Iceland of the cod, 206 in all, marked farther north in Disco Bay in 1935. On the other hand, a very extensive emigration has taken place from the Frederikshaab and Julianehaab districts.

4. Distribution of Recoveries in the Years after Marking.

Table 29 shows where the recoveries were made in the years after marking. At Iceland none was taken in the same year as the marking and the greatest number (38·4 %) were recaptured in the year following. Then there was a sharp fall; seven and eight years after the marking only one recapture is noted from Iceland, thereafter none at all. At Greenland on the other hand, several cod have been retaken more than seven years after the marking. Against two (0·4 %) retaken at Iceland seven and more years after the marking, at

Table 29. Recaptures from Greenland and Iceland in the years after marking.

Year after marking	Greenland No.	Greenland %	Iceland No.	Iceland %	Northern Zones I—VII Greenland %	Northern Zones I—VII Iceland %	Southern Zones VIII—IX Greenland %	Southern Zones VIII—IX Iceland %
1.[1])	97	15·9	—	—	17·0	—	12·8	—
2.	159	26·2	173	38·4	26·0	35·1	27·0	39·5
3.	116	19·1	127	28·2	19·3	37·8	18·4	25·0
4.	97	16·0	66	14·6	14·4	14·4	21·3	14·7
5.	56	9·2	42	9·3	7·7	7·2	14·2	10·0
6.	37	6·1	23	5·1	6·7	3·6	4·3	5·6
7.	14	2·3	18	4·0	3·0	1·8	—	4·7
8.	16	2·6	1	0·2	2·8	—	2·1	0·3
9.	8	1·3	1	0·2	1·7	—	—	—
10.	4	0·7	—	—	0·9	—	—	—
11.	—	—	—	—	—	—	—	—
12.	1	0·2	—	—	0·2	—	—	—
13.	1	0·2	—	—	0·2	—	—	—
14.	1	0·2	—	—	0·2	—	—	—

[1]) Marking year.

Greenland we have 31 (5·2 %) after seven and more years. Three specimens have been retaken even in the eleventh, twelfth and thirteenth year. Comparing the returns from the northern zones of Greenland (I—VII) with those from the two most southerly we see, that it was only in the former that cod were retaken such a long time after the marking.

In the two southern zones the conditions are almost the same as for Iceland. No marked cod were retaken in these zones later than seven years after marking. This we might have expected, since there is a spawning in the northern zones (III—VII) and the cod may remain there for the whole of their lives. No spawning has been noted in the southern zones, or but little, and most of the cod emigrate from there to spawn. As maturity begins as a rule at the age of 7 to 13 years, and almost all the cod marked were over 5 years old, it is natural that no recoveries were made more than seven years after marking.

5. Age Determinations on recovered Cod.

Table 30 shows the ages of the cod marked at Greenland and retaken at Greenland and Iceland. Unfortunately the fishermen who caught the fish have not in all cases sent in the otoliths. We have thus but a small material from the first years, especially from Greenland; from the middle of the thirties the returns have been considerably more complete. From Greenland we have received 304 samples of otoliths, from Iceland 247.

There is a very considerable difference in the distribution over the different age-groups in the two materials. The cod retaken at Greenland are distributed over far more age-groups than those recaptured at Iceland. In the case of the latter the age-groups VIII—XII account for no less than 86·2 %, whereas at Greenland they only give 50·6 %. There are many more of the old age-groups, XIII and over, in the Greenland recaptures, namely 34·8 %, whilst only 6·1 % of the Iceland recaptures comes from these old cod.

The quite young cod, V and VI, account for 4·3 % of the Greenland recaptures, but only 1·2 % of the Icelandic. Hence the cod retaken in Icelandic waters mainly belong to the middle-aged cod of the VIII to XII groups, thus exactly the years when maturity sets in for most cod and when the tendency to migrate is greatest. Naturally, the material may contain some cod which have several times made the journey to and from Iceland and it is also possible, that some of the cod have migrated to Iceland and stayed there for several years before being recaptured.

To obtain some idea of the age at which the emigration takes place and of the size when it begins, we may consider the cod retaken in the year after marking. That some of these may have undertaken the journey between Greenland and Iceland in earlier years, is

Table 30. Age Determinations on Cod marked at Greenland and retaken at West Greenland and Iceland.

Age-Group	Greenland No.	Greenland %	Iceland No.	Iceland %
V	3	1·0	—	—
VI	10	3·3	3	1·2
VII	13	4·3	16	6·5
VIII	18	5·9	42	17·0
IX	42	13·8	66	26·7
X	46	15·1	43	17·4
XI	20	6·6	38	15·4
XII	46	15·1	23	9·3
XIII	25	8·2	12	4·9
XIV	27	8·9	—	—
XV	22	7·3	3	1·2
XVI	14	4·6	—	—
XVII	13	4·3	—	—
XVIII	1	0·3	—	—
XIX	1	0·3	—	—
XX	3	1·0	1	0·4
Total...	304	100·0	247	100·0

of course not quite excluded. Age determinations have been made on 86 of the cod marked at Greenland and retaken in the following year at Iceland. Table 31 gives a summary of the results.

Table 31. Cod marked at Greenland and recaptured in the following year at Iceland.

Age-group	1930—32 No.	1930—32 %	1933—36 No.	1933—36 %	1937—39 No.	1937—39 %	Total No.	Total %
VI.....	1	4·8	1	3·0	1	3·1	3	3·5
VII.....	1	4·8	2	6·1	11	34·4	14	16·2
VIII....	2	9·5	7	21·3	12	37·5	21	24·4
IX	14	66·7	8	24·2	7	21·7	29	33·7
X	3	14·3	13	39·4	—	—	16	18·6
XI	—	—	1	3·0	—	—	1	1·2
XII	—	—	1	3·0	1	3·1	2	2·3
Total ...	21	100·1	33	100·0	32	99·8	86	9.99

All the recoveries belong to the age-groups VI to XII, most to VII—X. In the years 1930—36 most belonged to VIII, IX and X, in 1937—39 most were of the VII, VIII and IX groups. In the latter period there were far more of the younger cod migrating to spawn at Iceland, which may indicate an earlier beginning of maturity. Similar evidence of an earlier maturity has been obtained from examination of the otoliths (see pp. 27—28).

Fig. 25 shows the distribution of the age-groups of cod, marked in the northern zones (I—VII) and the southern (VIII—IX), and recaptured the following year at Iceland. On the whole the cod marked in the northern areas have been somewhat older than those marked in the southern. For the latter the age-groups VII—IX have been the most numerous, for the former X—XI.

We may now consider the year-classes which have migrated to Iceland. Fig. 26 shows how many of the different year-classes have been recaptured at Greenland and Iceland respectively. We see in the first place, that the recaptures at Greenland are far more evenly distributed over the different year-classes than the Iceland recoveries. The latter belong almost exclusively to the year-classes 1922, 1924, 1931 and 1932. The year-class 1926 only yielded 6·1 % of the recaptures at Iceland, though it was the most prominent among the recaptures at Greenland and was, on the whole, a year-class which had very great importance in the Greenland stock of cod for a long series of years (1930—41, see later). We do not know what may be the cause of this difference in the number of migrants to Iceland of the different year-classes. It is probable, that different hydrographical conditions prevail in the different years, stimulating or inhibiting the tendency to migrate.

Fig. 26 also shows the year-classes of marked cod, which have been retaken at Greenland and Iceland in the periods 1930—33, 1934—37, 1938—41 and 1941—46. At Greenland in the first period there were only three specimens belonging to the year-classes 1919, 1922 and 1924, and they have therefore been omitted from the figure. It will readily be seen, that the Greenland recoveries are spread evenly over all the large, good year-classes, whereas those from Iceland are concentrated on just a few. In the first two periods the Iceland recaptures belong chiefly to the year-classes 1922 and 1924. In 1938—41 ca. 60% belong to the year-class 1931 and over 20 % to the year-class 1932.

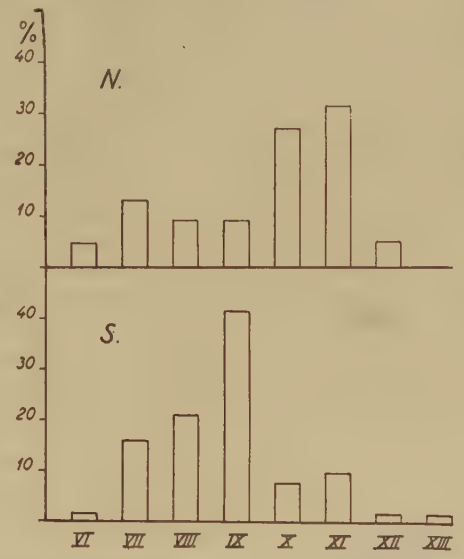

Fig. 25. Age Determinations of Cod retaken at Iceland in the year after marking.

N: Cod marked in the northern districts.
S; Cod marked in the districts of Frederikshaab and Julianehaab.

No marking experiments on the cod of West Greenland have been made since 1939[1]); consequently, the number of marked cod belonging to the younger year-classes varies considerably. The year-class 1936 was only three years old in 1939; its individuals were too small to be taken in the fishery and none of this year-class therefore has been marked. It is certain also, that but few of the rich year-class 1934 have been marked, partly owing to the small size of the individuals and partly because this year-class contributed in 1938 only ca. 17 % of the catches. In 1939 this year-class amounted to ca. 30 % in the two southern districts and ca. 20 % in the northern; about 230 cod of this year-class were marked.

The year-classes 1932 and 1931 were seven and eight years old when marked in 1939; theycon tributed between 10 and 20 % of the catches and their numbers had greatly decreased from the previous years. In the years 1936 to 1938 they formed a large proportion of the catches and, in consequence, a large number were marked. It will be seen from all this, that whilst we obtain a fairly good representation of the year-

[1]) After the war the marking experiments have been taken up again in 1946 and continued in 1947 and 1948. These experiments will, however, not be dealt with in the present paper.

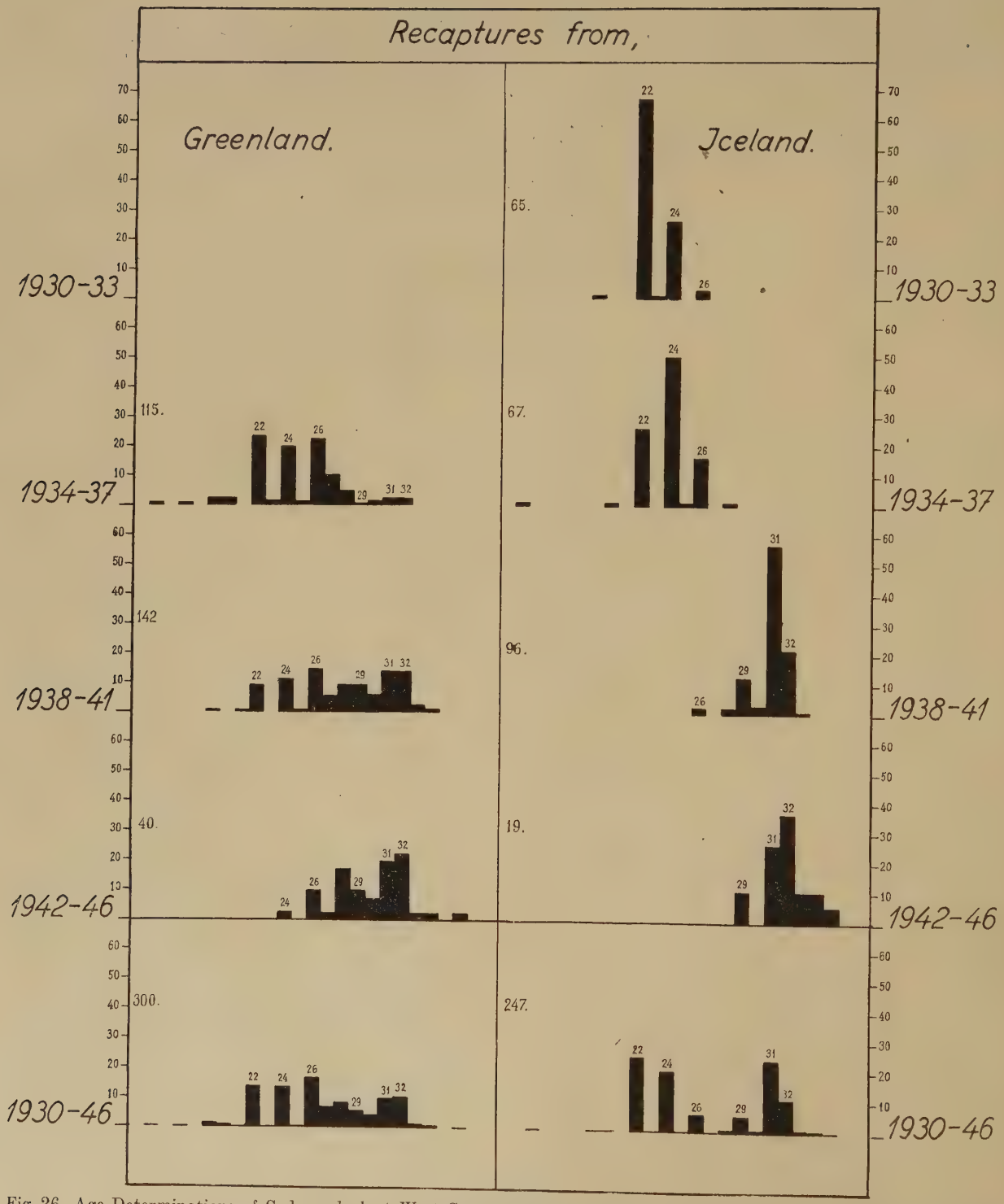

Fig. 26. Age Determinations of Cod marked at West Greenland and recaptured at Greenland and Iceland in the years 1930—33, 1934—37, 1938 -41 and 1942 -46, and for the whole period 1930—46. Percentage data. The figures to the left in each column indicate the number of age-determined Cod.

classes 1932 and 1931 and older among the migrants to Iceland, this is not got for the youngest, large year-classes of 1936 and 1934.

6. Size Distribution of recovered Cod.

Fig. 27 gives the distribution according to length of cod recaptured in the year after marking at Greenland and Iceland. The lengths on marking were arranged in 5 cm. groups. The heavy, continuous curve

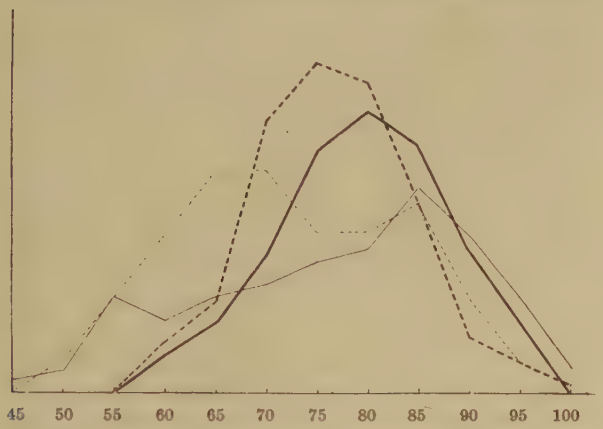

Fig. 27. Lengths of marked and recaptured Cod at Iceland (heavy curves) and at Greenland (fine curves). The continuous curves represent the Cod marked in the northern districts; the dashed curves those marked in the districts of Julianehaab and Frederikshaab.

shows the lengths of cod marked in the northern part of Greenland, zones I—VII, and recaptured at Iceland. The line of heavy dashes shows the lengths of the cod marked in the southern part of Greenland, zones VIII—IX, and retaken at Iceland. The two fine curves show the lengths of the cod recaptured at Greenland; in zones I—VII continuous curve, zones VIII—IX dashed curve. It will be seen, that the lengths of the cod recaptured at Greenland are distributed very evenly over small, medium-sized and large individuals, whilst those retaken at Iceland were mainly of medium-sized specimens, in length between 65 and 95 cm. with a maximum between 75 and 85 cm. Further, of the cod recaptured at Iceland those marked in the northern parts of Greenland are on the whole somewhat larger than those marked in the southern waters; just as we should expect, seeing that the emigrants to Iceland from the northern parts have been on the whole older than the migrants from the more southerly areas.

7. Recoveries from other Regions than Iceland.

Only two recaptures have come from other regions than the Icelandic, one from the Faroes and one from the Barents Sea.

The specimen from the Faroes was taken on Fuglø Bank (Bird Island Bank; 65°25′ N., 5°25′ W.) on 4. July 1938. It had been marked in the Lichtenau Fjord (60°37′ N., 45°15′ W.) on 15. August 1937 and had thus carried the mark for 7 to 8 months. It had travelled a distance of about 1,020 nautical miles.

The recapture from the Barents Sea was made on 2. March 1938 off Cape Kanin. This cod had been marked off Nanortalik 22. September 1932 and had thus carried the mark for over 65 months.

These two cod have presumably migrated from Greenland over towards the spawning grounds at Iceland. One has missed these grounds and gone on to the Faroes, where it was taken in April, i. e., the time of spawning. Even though there is only this one representative, we cannot exclude the possibility that Greenland cod sometimes reach the Faroes to spawn. From otoliths of spawning cod from the Norwegian Sea TÅNING has found, that some of these must have come from more northerly waters (TÅNING 1943). They have reached the Faroes presumably via Iceland.

The cod taken in the Barents Sea has possibly spawned in the interval on the Icelandic spawning banks. It is not probable that any emigration on a large scale is made to these distant regions, though we cannot exclude the possibility, that numbers of the very large quantities of cod, which in winter emigrate from Greenland towards the spawning grounds at Iceland, may wander out into the open Atlantic and possibly get lost there.

8. Recoveries at Greenland of Cod marked in other Regions.

a. Iceland.

During the period 1924—39 8,424 cod altogether were marked in Icelandic waters; of these up to 1940 a total of 1,015 had been recaptured or 12 % (TÅNING 1943). The percentage recovered is thus higher than for the corresponding experiments at Greenland. Of the 1,015 recaptures 19 were made in West Greenland waters.

TÅNING (1937) has given details regarding most of the recaptures. The immature cod in the coastal area of Iceland have been marked and the percentage recovered has been between 13 % and 34 % in the different experiments. No cod, marked as immature fish, has been caught in other areas. In the marking experiments carried out in spring on the Icelandic spawning grounds, Westmanna Isl., Selvogsbanki and mouth of Faxa Bay, the percentage recaptured has been lower than in the experiments in the coastal area, namely between 8 and 13 %. After spawning is over the cod scatter to seek food along the north and east coasts, where most recaptures have taken place in the autumn. Next spring they collect again on the spawning areas. The recoveries seem to indicate, that the cod does not return to the same spawning places every year.

The 19 cod marked at Iceland and retaken in Greenland waters were all caught in the summer and autumn. All had been marked in the spawning period,

March—April, at Westmanna; 5 were caught in July, 10 in August, 3 in September and 1 in October. Eleven were caught in the same year as the marking, 6 in the following year, one in the third and one in the fourth year after marking. The majority of the recaptures come from the marking experiment of 1931, namely 13, one each from the experiments in 1929 and 1932 and 2 each from the 1934 and 1938 experiments.

From the way the recaptures are distributed, there would seem to be a certain periodicity in the emigrations to Greenland. The 1931 emigration has been specially great.

As TÅNING observes, there may also be a food migration. The spent cod move from the spawning grounds to places where food is abundant. Considering the recaptures in the Greenland waters, as shown in Table 27, we see that most of the recaptures are concentrated on the banks, Store og Lille Hellefiske, in the zones II and III, with 7 and 5 recoveries. The 11 recoveries came from between 66°45′ and 67°41′ N. It is noteworthy, that most of the recaptures were made in the year 1931, a year when there were indications of extensive migrations in a northerly direction (HANSEN, JENSEN, TÅNING 1935, pp. 43—50). As mentioned earlier in this paper (p. 41), this northward migration could be observed directly; off Kangamiut in August large shoals of cod were seen going north after the lance occurring there in very large quantities.

The size of these cod from Iceland has been on the whole somewhat greater than that of the fish which migrated from Greenland to Iceland. The smallest was 81 cm. and the two largest 107 and 112 cm. when marked. More than half (10 specimens) had lengths between 90 and 94 cm. (cf. Fig. 27).

The speed at which the migration from Iceland takes place, is quite considerable. The average minimum for the 11 cod retaken in the same year as the marking is shown in the following table.

Table 32. Rate of Migration.

Recaptures of Cod

A		B	
Marked at Iceland and recaptured at Greenland		Marked at Greenland and recaptured at Iceland	
Miles per day	No. of Spec.	Miles per day	No. of Spec.
7·0— 7·5	2	2·0—2·5	15
7·5— 8·0	2	2·5—3·0	57
8·5— 9·0	1	3·0—3·5	44
9·0— 9·5	1	3·5—4·0	20
10·0—10·5	3	4·0—4·5	18
11·0—11·5	2	4·5—5·0	6
		5·0—5·5	6
		5·5—6·0	—
		6·0—6·5	—
		6·5—7·0	—
		7·0—7·5	1

Comparing columns A and B in Table 32 we see that the minimum rate of migration from Iceland to Greenland has been almost twice as great as for the cod migrating from Greenland to Iceland. In the latter case the average minimum rate has been between 2 and 5·5 miles per day. Only one cod has attained to 7·2 miles per day.

Whether the cod marked at Iceland and retaken at Greenland belong to Icelandic waters and only occasionally migrate over to Greenland after spawning, or whether it is a migration of Greenland cod to Iceland and back again, is a question difficult to answer. No recoveries have been made at Greenland of the immature cod marked at Iceland; this may indicate, that the cod that grow up in Icelandic waters do not migrate to Greenland. More extensive marking experiments are very desirable in the Iceland waters, especially on the different spawning grounds. As mentioned by TÅNING (1934—37) and also noted earlier in this paper, it is probable that an essential portion of the stock of cod in southern Greenland is replenished by drafts of young from the spawning grounds of Iceland; this had been made evident by the "Dana" investigations of 1931. It may be assumed, that the large quantities of small cod, which have appeared some years in the Julianehaab district, where no spawning places of the cod have been found, come from the fry which have drifted over from Iceland (see pp. 29—31). For this reason and also from the fact, that so many cod marked in southern Greenland have been retaken at Iceland in the spawning period, the cod there may be regarded as a stock which grows up at Greenland but has its spawning grounds in Icelandic waters.

b. Newfoundland.

THOMPSON (1943) mentions two cases where cod marked in the Newfoundland area have been recaptured in the waters of Greenland. One was marked at Indian Islands, Labrador, 7. July 1934 and recaught in August 1938 off Store Hellefiske Bank, 67°28′ N., 54°21′ W. The other was marked in July 1935 on the southern Grand Bank and recaptured in October 1936 at 67°54′ N., 54°36½′ W., thus quite near to the first. The Portugese fisherman who reported the 1936 recovery had given so little information about it, that THOMPSON at first regarded it as doubtful. But when the 1938 recapture became known, there seemed no reason to doubt, that the first had really come from the waters of Greenland. It is possible, therefore, that cod from Labrador and Newfoundland can migrate into the West Greenland area.

These may have been a few stragglers, however; so far as known, the stocks at Canada and Greenland have nothing to do with each other. The number of vertebrae is very different in the two stocks (cf. pp. 43—48) and so far no cod marked at Greenland have been recovered on the American side of Davis Strait. We have, it is true, one recapture at Newfoundland in 1933 of a cod marked at the Westmanna Islands in 1931, and we may suppose this to have reached there via West Greenland; from Greenland it has

Table 33. **East Greenland Marking Experiments.**

No. marked	Year of marking	Recovered pr. year Gr.	Recovered pr. year Ic.	Year of Recapture 1st Gr.	1st Ic.	2nd Gr.	2nd Ic.	3rd Gr.	3rd Ic.	4th Gr.	4th Ic.	5th Gr.	5th Ic.	6th Gr.	6th Ic.	7th Gr.	7th Ic.	8th Gr.	8th Ic.	Total Recoveries Gr.	Total Recoveries Ic.	Year of marking
100	1927	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	2	1927
11	1928	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1928
—	1929	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1929
182	1930	1	—	1	—	—	—	—	—	—	1	—	—	—	1	—	—	—	—	1	2	1930
243	1931	1	2	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1931
34	1932	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1932
200	1933	—	1	—	—	—	3	—	8	—	—	—	1	—	1	—	—	—	1	—	14	1933
				—	1	—	3	—	9	—	—	—	1	—	1	—	—	—	1	2	18	
Year of Marking				1933		1934		1935		1936		1937		1938		1939		1940				

The two cod marked in 1926 are not included in this table.

been carried by the west-going current over to the Labrador Current, which has brought it to the north coast of Newfoundland at 50°58′ N., 55°48′ W. (TÅNING 1934, p. 788). But in this case also it is only a matter of an occasional straggler. Considering the intensive fishery carried on at Newfoundland and the numerous marking experiments at West Greenland over a number of years, it would seem reasonable to expect, that some of the Greenland marked cod would be recaptured at Newfoundland, if any such migration from Greenland to Newfoundland really took place, even to a small extent.

9. Marking Experiments at East Greenland.

In the years 1926—32 on the initiative of Prof. JOHS. SCHMIDT 572 cod were marked in the Angmagssalik district by the manager of the colony A. T. HEDEGAARD. On the 7th "Thule" expedition of KNUD RASMUSSEN in 1933 a further 200 were marked in this district by stud. mag. E. BERTELSEN. Thus 772 cod altogether were marked in the period 1926—1933. The number of recoveries from all experiments has been 20, two of which have been made at Greenland, the others at Iceland. The accompanying Table 33 gives a summary of the recaptures. It will be seen, that there were only 6 recoveries from the 1927—32 markings, though 570 had been marked, whilst no fewer than 14 come from the 200 cod marked on the 7th "Thule" expedition in 1933.

The table shows the distribution of the recaptures over the years of marking. The 2 recaptured at Angmagssalik were both taken in the year of marking. The recoveries at Iceland are spread over the second to the eighth year. The greatest number was retaken in the third year, thus about 2 years after the marking. The age of only 7 of the recaptures could be determined as it was only in these cases that otoliths as well as marks were sent in. They were all retaken at Iceland. The recaptures come from the following age-groups; one from each of the groups IX, XI, XII, XV and XVI and two from X. The distribution according to year-classes is:

Year-class	No.
1922	3
1924	3
1926	1
	Total: 7.

We have here the same year-classes as were abundant on the west coast. As with the recoveries at Iceland of the cod marked in West Greenland, most belong to the year-classes 1922 and 1924.

These experiments show, as one might expect, that the cod stock of East Greenland has a close connection with Iceland.

B. Fluctuations in the Stock of Greenland Cod.

1. Fluctuations in the Size of the Cod.

All the cod from which otoliths were taken to determine the age, were measured from snout to end of tail; all the cod when marked were measured in the same way. In several cases also measurements were taken of the cod from the catches of the Greenlanders at the various fishery stations. In comparison with the many years of the investigations the number of measurements is not great, contrasted especially with the numbers in other countries where similar experiments were carried out, e. g., Norway and Iceland. Altogether 75,440 measurements were made in the period 1924 to 1939. Measurements from the period 1940 to 1946 are not included.

These measurements from 1924—39 are represented in Fig. 28. For the sake of comparison three areas are distinguished; the northern area including the coasts and fjords of the Godthaab district and farther north (zones I—VII), the southern area embracing coast and fjords in the Frederikshaab and Julianehaab districts (zones VIII—IX) and thirdly, the banks, meaning all the banks lying off the west coast of Greenland, chiefly Fylla and Store and Lille Hellefiske Banks. The number of measurements was 39,590 from the northern area, 19,525 from the southern and 16,325 from the banks. The material is divided into 5 cm. groups.

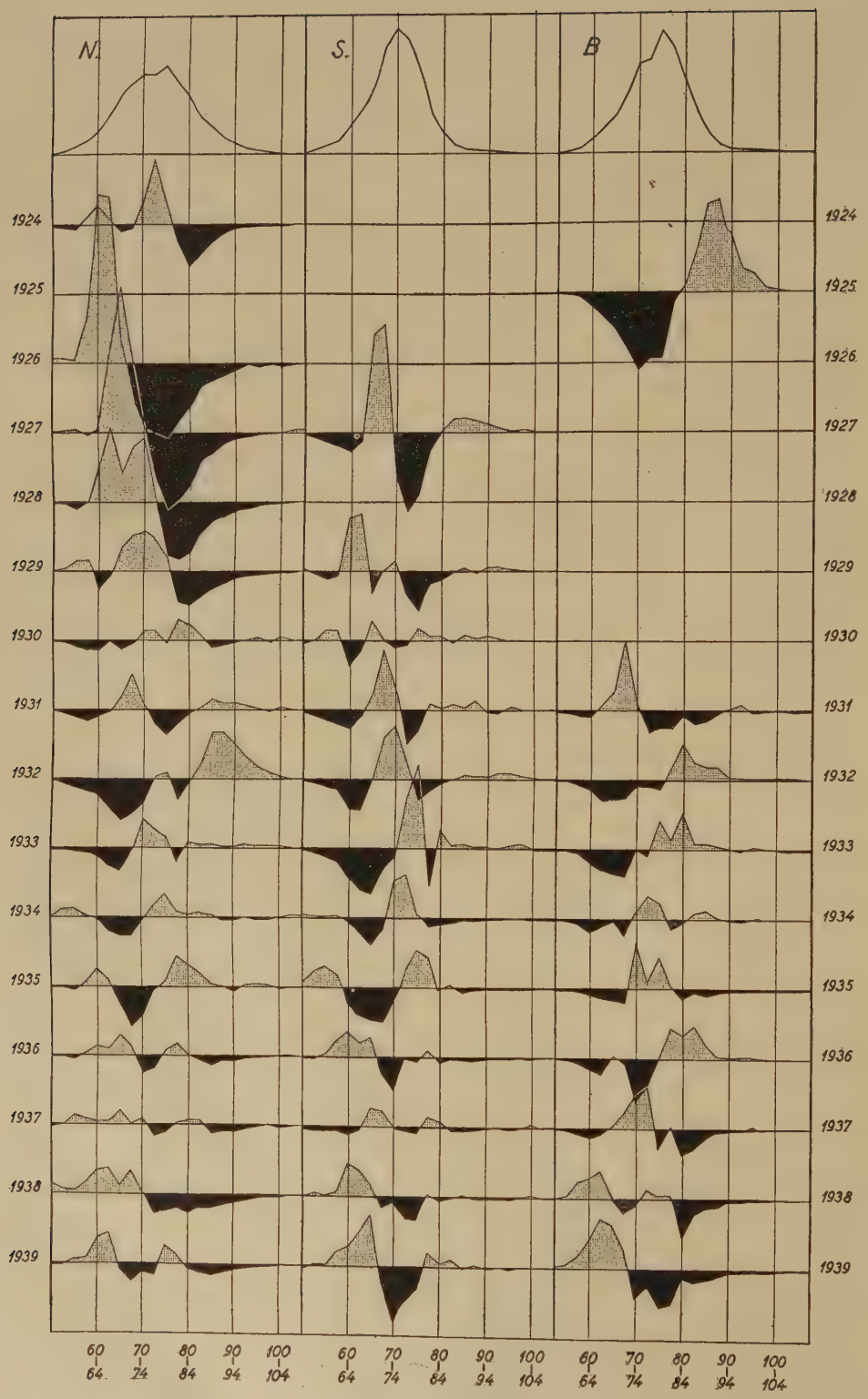

Fig. 28. Size of the Cod. See text p. 63.

Uppermost in Fig. 28 we have curves for the average lengths of cod from each of the three areas for all the years in which measurements were taken. These average curves differ somewhat from each other; in the northern area there is a fairly even distribution of the sizes, whereas in the southern many more are concentrated about the medium sizes. Here about half lie between 65 and 79 cm., whereas barely a third lie between these sizes in the northern area. On the banks the average lengths are higher than in the other two areas. In the southern area only about 42 %, in the northern about 58 % are over 75 cm., whereas on the banks about 67 % are over this size.

The lengths are in good agreement with the known conditions, namely, that both young and older age-groups occur in the north, mainly the middle-aged groups in the southern area and very large, old cod on the banks. It may be remarked, that the average curves are not comparable in detail, as they are not based on the same number of samples in the different areas. Whilst the curves in the northern and southern areas are calculated for the period 1929—1939, the averages for the banks are for the period 1931—1939.

The curves for the different years are drawn from deviation curves calculated from the averages. The positive portions of the curves are indicated by dots, the negative are black; in most cases the deviation curves resemble each other in all three areas. The peaks show the good, large year-classes in the catches. We can see when these enter into the catches for the first time and follow them through the years. For example, the year-classes 1922, 1924 and 1926 can readily be followed in the first years and later, the 1931, 1932 and especially 1934 year-classes are seen to dominate in 1939 in all three areas. The deviations are greatest in the first years, when only a few large year-classes occur.

2. The Year-Class Composition of the Greenland Cod in the Years 1924—46.

To investigate the composition in year-classes of the Greenland stock of cod, extensive collections of otoliths from different localities were made in the period 1924—46 (for the material see pp. 31—32).

It is impossible to give a complete picture of the composition in an area of both quite young and older year-classes, as the cod of about the same size keep together in shoals. The cod is a greedy, rapacious fish that does not spare its own species and the small cod seek localities away from the older and larger. The small cod live in the summer in quite shallow water close to the shore, whilst the larger cod as a rule live in deeper water, either near the bottom or in the surface waters. The very large cod have a special tendency to keep near the bottom. The small and large cod are not usually taken with the same apparatus. The smallest are only taken by means of drag-seines from the shore, whilst the larger cod are taken with the hook (jig, hand-lines and long-lines), gill-nets and trawl. Cod of the sizes about 30—40 cm. are

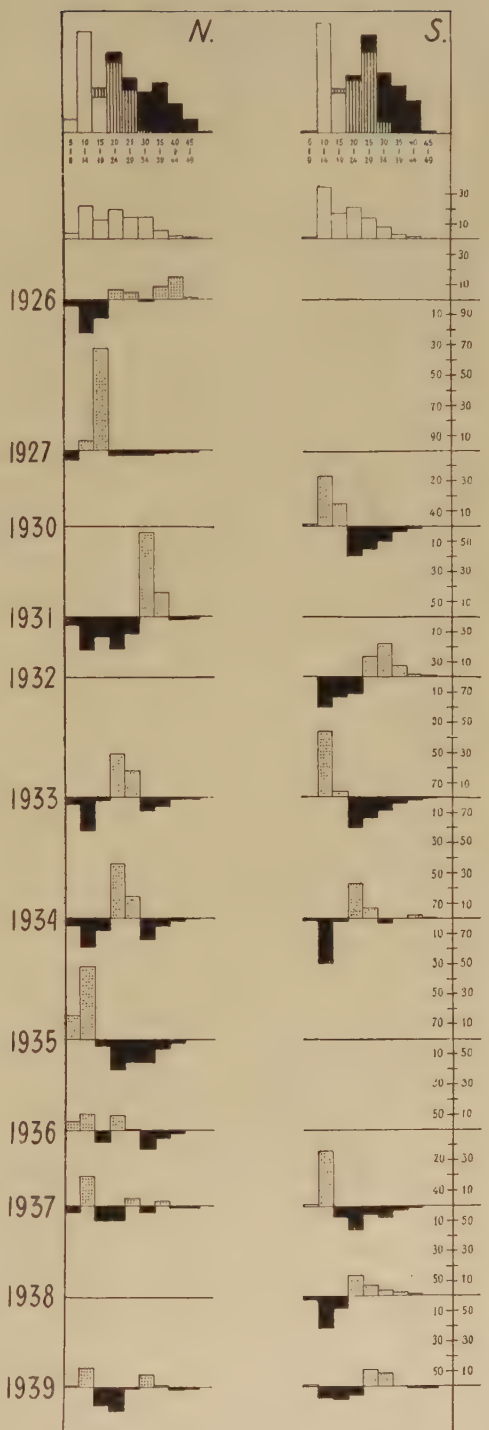

Fig. 29. Measurements of small Cod of the I- to III-Groups, in 5 cm. Grouping. Uppermost: the distribution of the lengths of the I- to III-Groups. Second from the top: Distribution of the average lengths for the years 1936–39. Deviations from the averages in the different years.

difficult to catch, whether with the seine or the commercial gear; they are most readily taken as a rule with the small, shining jigs. It will be understood from this, that one is obliged to keep the small and larger cod separate when investigating the year-class composition of the cod stock.

a. Investigations on the earliest Age-Groups of the Cod.

The material of the small cod has been almost entirely collected by means of the eel-seine, a small portion however by the jig. The specimens taken by seine are counted immediately on capture and the total length measured from snout to tip of tail, either in mm. or, as a rule, in cm. down to the nearest whole cm. In small catches all the specimens have been measured; otherwise a suitable number has been selected by chance and then measured. As control of the determinations, samples of otoliths have been taken for many of the catches, in all 2,274. This has only been done in a few cases for the I-group, as this group is fairly easily separated from the measurements alone; the overlapping of the largest I-group with the smallest of the II-group is very slight. More considerable is the overlapping between the II- and III-groups (see uppermost figure, Fig. 29). In most cases nevertheless the measurements alone give a fairly good representation of the age-groups in the catches. When we have age-analyses from otoliths as well as the measurements, the material is well-suited to display the occurrence of the youngest age-groups.

Fig. 29 gives the measurements from the different years as deviation curves from an average for each of the two areas (zones I—VII and VIII—IX). The measurements are arranged in 5 cm. groups and the figures indicate percentages. In the second figure from above the average curves represent the measurements of the cod taken in seines in each of the two areas. In both the measurements are distributed much in the same way, with most of them grouped between 10 and 40 cm. Comparing these curves with the curves for age analyses (cf. Fig. 29 top) we see, that the I- and II-groups are present in the catches in almost the same quantities, whereas specimens of the III-group occur more rarely. In the samples from the southern areas the I-group occurs more frequently than in the samples from the northern areas, but the reverse has been the case with group III. This may not be taken as a general rule, however, as the samples from the two areas have been caught in different years and we have thus to take into account the fluctuations in the quantities of the different age-groups. It was only in the years 1933, 34, 37 and 39, that samples were taken in both areas.

In a later section dealing with the fluctuations in the age-group composition of the commercial catches, the importance of the separate age-groups will be discussed in more detail. It need only be remarked here, that the age-groups prominent in the eel-seine catches have also appeared as rich age-groups in the stock of older and larger cod taken by the commercial catches in the years under review. According to the regulations governing the preparation of saltfish for export, only fish larger than ca. 60 cm. are used. This size is reached by most cod only in their sixth year, thus of the V-group. We should thus as a rule be able to forecast, from an examination of the quantities in the I- and II-groups taken by the eel-seine, whether a rich age-group will make its appearance in the commercial catches four to three years later.

In each of the years the fishery investigations have been carried on, the annual report has referred to the age-groups which are growing up and will be of importance in the commercial catches in the years to come. These estimates have proved to be correct in by far the most cases, as can be seen from the summary below. This has been worked out from the author's annual reports, in which on the basis of the eel-seine catches of the I-, II- and III-groups forecasts were made as to what groups would become of importance in the practical fishery of the Greenlanders. The symbols used indicate: excellent +++, good ++, fairly good +, poor — and bad ——.

Table 34. Forecasts on the Basis of the young Age-Groups.

Year-Class	Age-Group I	Age-Group II	Age-Group III	Importance in the Fishery
1922	..	+++	+++	+++
1923	..	—	—	—
1924	+++	+++	+++	+++
1925	—	—	..	—
1926	+++	++	++	+++
1927	..	—	—	—
1928	++	—	—	—
1929	++	+	++	+
1930	—	..	..	—
1931	—	++	..	++
1932	++	+++	+	++
1933	—	—	—	—
1934	+++	+++	..	+++
1935	—	..	+	+
1936	+++	+++	+++	+++
1937	—	—	..	—
1938	—	..	..	—

In the 1946 and 1947 investigations the seine catches yielded good quantities of cod belonging to the I- and II-groups, thus indicating that the 1945 year-class was abundant; in 1950 it should be prominent in the commercial catches in the Greenland waters. In 1948 much greater quantities of I-group cod were found along the whole coast from Julianehaab district up to Umanak Fjord than in any earlier year. Thus year-class 1947 seems to be very rich and will certainly prove to be of very great importance in the future from 1952 on.

b. The Year-Classes of Cod in the Commercial Catches.

A very important branch of the investigations on the biology of the food-fishes has been concerned with the composition of the stock year by year and

Table 35. Percentage in 1940—47 of the Age-Groups in the Catches.

A. Northern Districts (zones I—VII).

	1940	1941	1942	1943	1944	1945	1946	1947
No. analysed	505	205	304	719	1221	2849	456	1171
Age-Groups	Percentage							
IV	—	—	—	0·3	0·9	0·9	10·3	0·2
V	9·1	**2·4**	1·6	0·1	6·2	2·7	8·8	6·1
VI	**31·3**	2·4	**25·7**	1·5	5·3	6·0	4·6	3·6
VII	6·7	**8·8**	9·5	**9·2**	4·6	1·9	3·5	5·4
VIII	**9·3**	1·5	**14·1**	5·3	**18·8**	2·8	3·3	5·0
IX	**8·9**	**5·4**	3·3	**33·2**	8·5	**26·4**	2·6	1·8
X	2·4	**14·1**	**8·2**	6·5	**30·1**	8·6	**14·9**	3·4
XI	5·3	2·9	**8·9**	**8·9**	4·5	**32·1**	3·9	**15·4**
XII	4·0	10·7	1·6	**16·8**	**6·6**	5·0	**24·8**	12·1
XIII	5·0	15·1	9·2	2·2	**6·5**	**7·2**	2·2	**30·3**
XIV	10·7	6·8	5·9	5·3	1·6	**3·2**	**15·8**	4·4
XV	0·8	19·5	4·6	2·6	1·5	1·2	**0·7**	**4·9**
XVI	4·6	2·9	6·6	1·4	1·4	0·7	0·9	**5·0**
XVII	—	5·9	—	5·3	1·2	0·3	0·9	1·5
XVIII	1·4	—	0·3	0·1	1·4	0·5	0·7	0·3
XIX	—	1·5	—	0·4	—	0·4	0·7	0·3
XX	—	—	0·3	—	0·4	0·1	1·3	0·1
XXI	0·6	—	—	0·4	0·2	0·1	—	0·3
XXII	—	—	—	0·1	0·3	—	0·2	—
XXV	—	—	—	—	—	—	—	0·1

Total number analysed: 7430.

B. Southern Districts (zones VIII and IX).

	1940	1941	1942	1943	1944	1945	1946	1947
No. analysed	1119	615	198	1550	401	338	949	759
Age-Groups	Percentage							
IV	**6·8**	2·0	—	0·3	0·3	—	3·0	0·9
V	13·0	**14·8**	1·0	0·4	0·5	1·8	2·2	8·0
VI	**26·7**	18·7	**40·4**	2·7	1·7	7·9	1·5	2·2
VII	11·4	**11·4**	18·7	**30·3**	6·0	4·4	6·4	3·2
VIII	**9·8**	4·7	**29·3**	17·0	**34·9**	7·1	6·2	5·1
IX	**6·5**	**4·9**	0·5	**17·9**	9·5	**19·8**	6·2	5·3
X	2·1	**6·7**	**3·5**	4·6	**31·2**	11·5	**29·2**	3·8
XI	4·0	3·3	**1·5**	**6·1**	1·7	**25·7**	8·7	**20·6**
XII	2·3	6·2	0·5	**6·6**	**5·5**	8·6	**18·7**	9·0
XIII	4·2	7·0	1·0	2·6	**4·7**	**5·0**	2·7	**28·9**
XIV	7·2	5·2	—	4·1	0·3	**3·8**	**8·2**	4·6
XV	1·0	10·1	1·0	1·9	1·7	1·5	**1·9**	**4·0**
XVI	3·4	0·5	2·0	3·2	0·3	1·8	1·8	**2·6**
XVII	0·3	2·6	—	1·4	0·3	0·6	0·6	0·1
XVIII	1·3	0·2	0·5	0·2	0·5	0·3	1·1	0·5
XIX	0·1	1·8	—	0·3	—	—	0·3	0·5
XX	—	—	—	0·1	0·5	—	1·3	0·1
XXI	—	—	—	0·1	—	—	—	0·5
XXII	—	0·2	—	—				

Total number analysed: 4929.

with the fluctuations in richness of the various year-classes, with a view to making forecasts regarding the future product of the fishery. Such investigations, so far as the cod is concerned, have been carried out in Norway by Hjort, Sund and Rollefsen; in Icelandic waters by Täning and Friðriksson and at the Faroes by Täning. From Newfoundland and Nova Scotia we have the investigations of Harold Thompson. The methods employed have meant the collection of large materials of length measurements and age determinations from the scales and otoliths.

In the first period of the investigations the scales were mainly used for the age determinations, but later investigators changed over to the exclusive use of the otoliths. The scales of the cod, unlike those of the herring, are not so well suited for the age determinations since the year-rings are only clear in the young age-groups. In cod of eight years and older the outermost winter-rings become indistinct, making an exact determination of the age difficult. The otoliths, on the other hand, give in most cases a much more certain determination even for the older age-groups.

Otoliths have been exclusively employed in the Greenland investigations. With regard to the collection of this material and the methods of determining the age, see pp. 31 and 32.

The ideal material for a study of this kind would be collections of the same number of otolith samples at the same localities and at the same part of the season, each year. But it has not been possible to procure such materials, for practical reasons. The samples could not be collected from the same stations every year, and the number of samples from the various stations has also been very different. At some stations several hundred otoliths have been obtained at others a much smaller number. The times when the collections were made has varied, though most have been obtained at the main period of the Greenland fishery, in the months of July, August, September.

It should be noted, that the analyses of the stock year by year only give the relative proportions of the age-groups in the catches and not the actual quantities in the sea of these groups. For such a determination the analyses are not suited, as it is not yet possible to make any estimate of the fishing intensity from the available fisheries statistics of Greenland. This may perhaps be possible in the future, when the statistics will be collected in a different way.

A significant factor in the search for representative samples of the stock of cod in the sea is the selectivity of the fishing gear. In the Greenland fishery jigs (trolling), hand-lines and long-lines are mainly used. Nets can only be used at a few places, Amerdlok and Ikertok Fjords in the Holsteinsborg districts and Angmagsivik in the Sukkertoppen district, at the time when the capelan migration is going on, and this gear is thus of no importance. In the earlier years hand-lines and jigs were almost exclusively used in the cod fishery, but during the thirties the long-line fishery has developed more and more and may now be said to be the principal fishing gear of the Green-

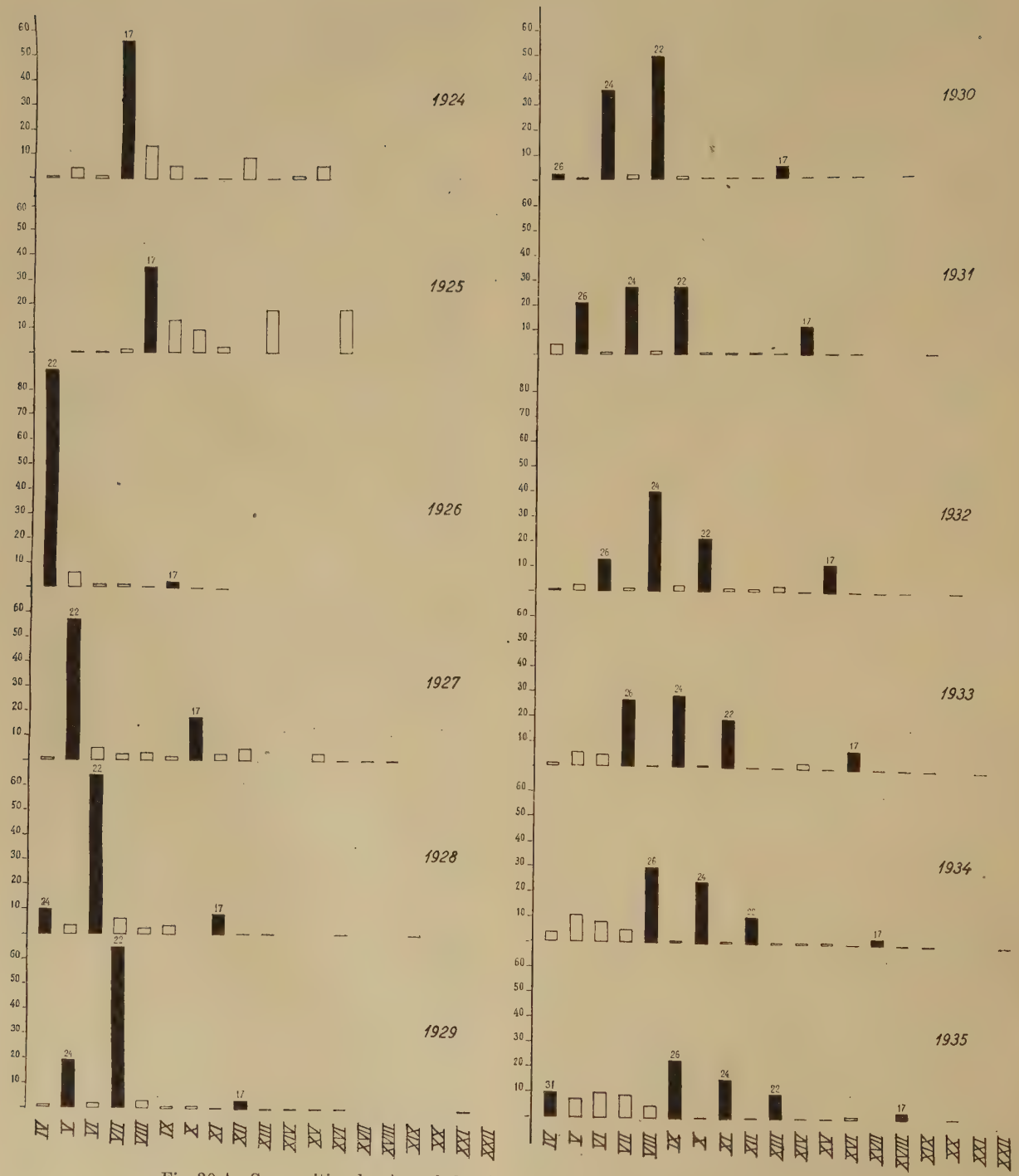

Fig. 30 A. Composition by Age of the Greenland Cod Stock in the years 1924—35.

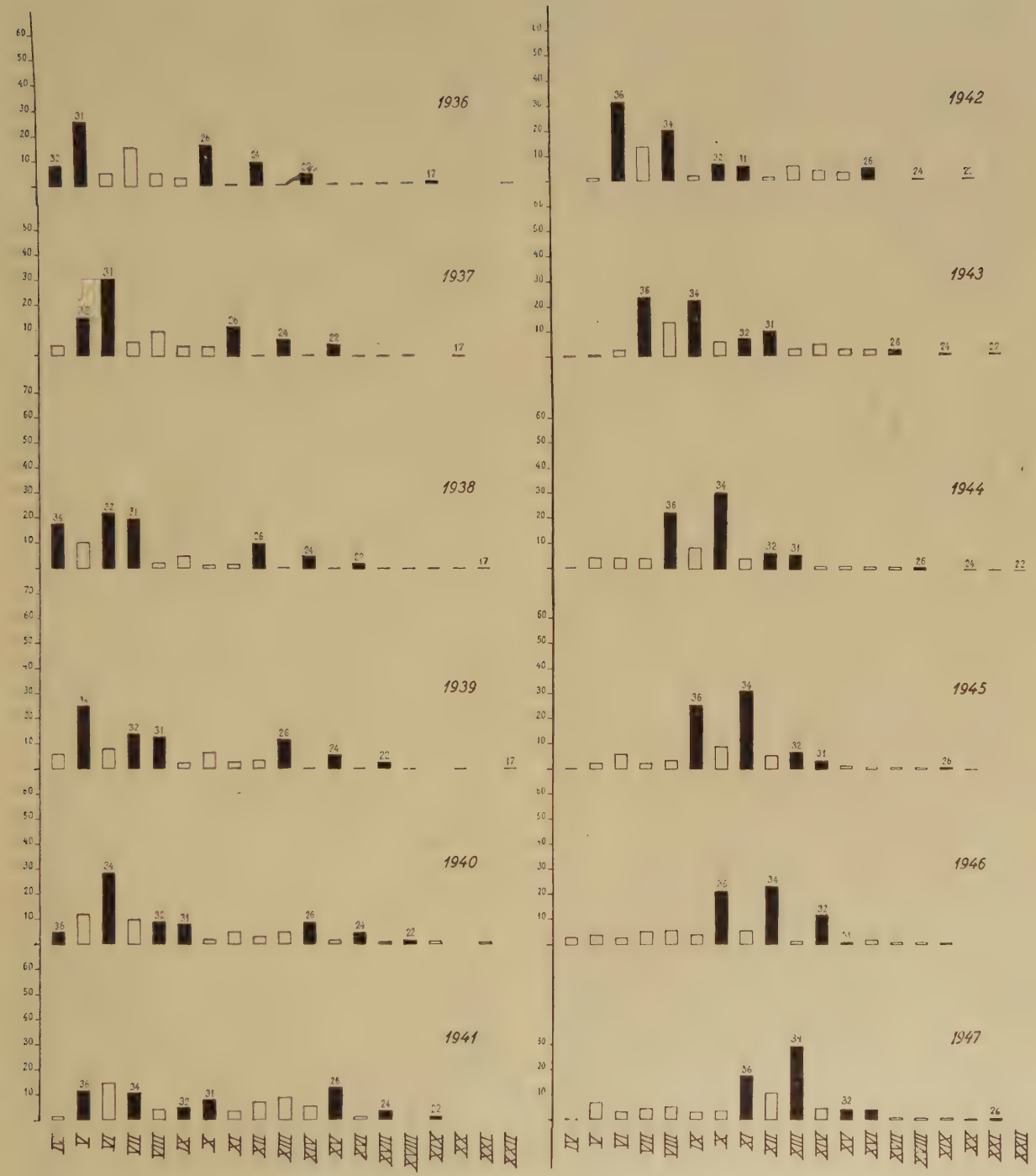

Fig. 30 B. Composition by Age of the Greenland Cod Stock in the years 1936—47.

landers. The collections of otoliths from the later years practically all come from the cod taken by long-lines.

My impression is, that the selectivity of the gear used in the investigation of the cod stock in Greenland waters has been of less importance than in other waters, e. g., Iceland where nets are used to a great extent. One cannot ignore the possibility, however, that in the first years of the investigations, when the fishery was mainly carried on by jigs, some age-groups have been too strongly represented in the catches by comparison with their actual quantities in the sea. This applies especially to the 1922 year-class.

In the *Annales Biologiques 1943*, pp. 108—109, the present author has discussed the age-group composition of the catches made by the Greenlanders in the years 1924—39.

Table 35 shows the age analyses of the catches in the different years from the two areas, northern districts (zones I—VII) A and southern districts (zones VIII—IX) B for the period 1940—47. A graphic representation of the results of the age analyses in 1924—47 is given for both areas and the banks in Fig. 30. The number of the determinations has varied somewhat in the different years; the greatest number is from the northern area, 28,438, from the southern we have 18,483 and from the banks 3,362.

The III-group is omitted from these summaries; owing to the small size of the individuals it is not well represented in the catches. The IV-group also is possibly not well represented in all the catches, as the size lies below the limit, ca. 60 cm., set by the Greenland Administration as the minimum for the cod to be landed and prepared for export. It is possible namely, that these undersized fish are not always brought to land but thrown overboard after capture. And it is also possible, that the smallest specimens of this age-group are too small to be taken by the fishing gear ordinarily used. The same is the case with a number of the V-group. It is only in the catches of the Greenlanders when fishing for themselves, that the IV-group may not be fully represented. Instructions have always been given to the fishermen to bring in the whole catch, including the small, on the days when samples for analysis were wanted.

From the table and Fig. 30 we see that very great fluctuations occur in the size of the year-classes. Large, good classes alternate with small. Eight good years occur in the years of the investigations: 1917, 1922, 1924, 1926, 1931, 1932, 1934 and 1936. From an earlier period there are signs of some good years which may have played a great part in the stock of that time: 1912 and 1909. The 1919 year-class, which is known to have been abundant both at Iceland and Norway, has not been so numerous when young in the Greenland stock, yet seems as older fish to be the class which, after the 1917 year-class, has been the most abundant among the year-classes older than 1922.

The 1922 year-class has been the most abundant of all year-classes that have occurred at Greenland up to 1939. From the time when it first entered the catches, as IV-group, in 1926 and till 1929 it contributed over 60 % of the cod taken by the Greenlanders. In 1926 it amounted to as much as 87·9 % of the cod taken in the northern districts. Even if it has played such a large part in the catches, it has certainly not amounted to such a large percentage in the actual stock. Its large proportions in the catches may have come from its living in shallower water with a greater tendency to take the bait than the large, older cod. In these years the cod of this group literally swarmed everywhere in the coastal waters and in the fjords, both right inshore and farther out. The fish were often in such dense shoals, that the hand-line could not be sunk to the bottom, so keen were they to snap at the bait; consequently, it was difficult to get at the larger and older cod which as a rule keep down below and do not take the hook so readily. Several times in calm weather the author has stood on the rocks and watched enormous numbers of these smaller cod so densely packed that one could hardly see the bottom even in the shallow water. All about, small children as well as old folk, took part in the fishing at this time and it proved of immense importance to the population. The cod fishing became the staple industry in South Greenland. As XIII-group the 1922 year-class still yielded about 10 % of the cod taken; at this age it had an average weight of about 7·5 kg. and was thus obviously of great importance in the fishery. As XIV-group in 1936 it contributed only a little over 5 % and decreased still further in the following years. The last individuals of the 1922 class were found in 1944. In the more northerly districts (zones I—VII) it was represented by about 0·3 % in the catches.

The marking experiments have shown, that the cod of this year-class (1922) migrated in large numbers to Iceland; more of this class have been retaken at Iceland than of any other one. The 1924 class has also been abundant but its importance for the fishery has not been so great; in 1930—35 as VI- to XI-group it seems to have been specially abundant in the two southern districts. In 1936 it shows a sudden drop with the appearance of the 1931 and 1932 classes, right down to 5·6 % and to slightly over 3 % in 1938 and 1939.

The marking experiments have also shown a great emigration to Iceland of the 1924 class. In the southern districts it was detected for the last time in 1944, when as XX-group it composed 0·5 % of the catches; in the northern districts it yielded 0·2 % of the catches in 1946.

The 1926 class stands No. 3 in the series of year-classes which have been of importance in the Greenland stock of cod during the years of investigation. It seems to have occurred in greatest numbers in the northern area, in contrast to the 1924 class which was most abundant in the southern parts. It maintains itself fairly uniformly until 1942 when as XVI-group it falls right down to 6·6 % from 19·5 % in the

previous year. In 1946 it amounted to only 1·3 % of the material examined. In the two most southerly districts it drops from 10·1 in 1941 to 2·0 % in 1942. It is not present in the 1945 material, but in 1946 it shows 1·3 %, thus the same amount as in the northern districts. By comparison with the 1922 and 1924 classes but few specimens of this year-class have been retaken at Iceland, according to the marking experiments. It has to be noted, however, that the year-class 1926, as mentioned above, occurs most abundantly in the northern districts, from which emigration is less than from the southern.

After the 1926 class the later year-classes have no great importance. Yet the 1929 class has been prominent to some extent in 1935—37 in the southern area. Then we have suddenly two good year-classes one after the other, 1931 and 1932. The 1931 class in the southern districts fell greatly already in 1939, to 9·2 % from 22·8 % in 1938; after that it has been below 10 %. In the northern districts it is 1940 before it falls below 10 %. For the next three years it fluctuates between 8·9 and 16·8 %, then drops suddenly to 6·5 % and in 1946 amounted to only 0·7 % in the samples.

The 1932 class was very abundant in both areas; in 1938 it reached over 20 % in the northern districts and amounted to 26·6 % in the southern. In both it fell considerably in 1939 and since 1940 it has been below 10 % except in 1946, when against all expectations it rose to 15·8 % in the northern districts. It also rose in the southern areas but here only to 8·2 %. The reason for the sudden drop in both year-classes 1931 and 1932, was assuredly the great migration to Iceland of these two year-classes.

The 1934 and 1936 year-classes have been the ones which have had the greatest influence on the Greenland cod fishery in recent years. The former already in 1938, when as IV-group it entered the catches for the first time, amounted to no less than 18·6 % in the northern districts and 16·7 % in the southern. The 1922 class is the only one which, as IV-group, has yielded a larger proportion of the catches. In the northern districts the 1934 class has amounted to over 30 % in the samples from the years 1940, 1943, 1944, 1945 and 1947 and in the southern districts it has been over 30 % in the years 1939 and 1944. In 1946 when this class was 12 years old it contributed 24·8 % to the catches in the northern districts and 18·7 % in the southern. Among all the other rich classes occurring in the Greenland cod fishery, not one so far yielded as XII-group such a large percentage of the catches. For example, the large year-classes 1922, 1924 and 1926 have as XII-group only given respectively 12·6, 12·0 and 13·2 % in the northern and only 5·8, 5·6 and 4·6 % in the southern districts.

The year-class 1936 has yielded a somewhat larger percentage in the southernmost districts than in the northern; in 1942 and 1945 only just over 2 % in the northern districts against over 20 % in the southern, in 1942, 1943, 1944 and 1946. It was nearly 20 %, namely 19·8 %, in 1945. In 1946 the 1936 class dominated in the southern districts (29·2 %) but in the northern lay under both the 1934 and 1932 classes with respectively 24·8 % and 15·8 %. All the year-classes later than 1936 have been quite inconsiderable in the commercial catches, except the 1942 class, which as IV-group amounted in 1946 to 10·3 % in the northern districts; none of them has yielded over 10 %.

As noted above, evident also in Table 35, there is some difference in the fluctuations of the year-classes in the two areas, zones I—VII and zones VIII—IX. This difference is clearly seen in Fig. 31, where the

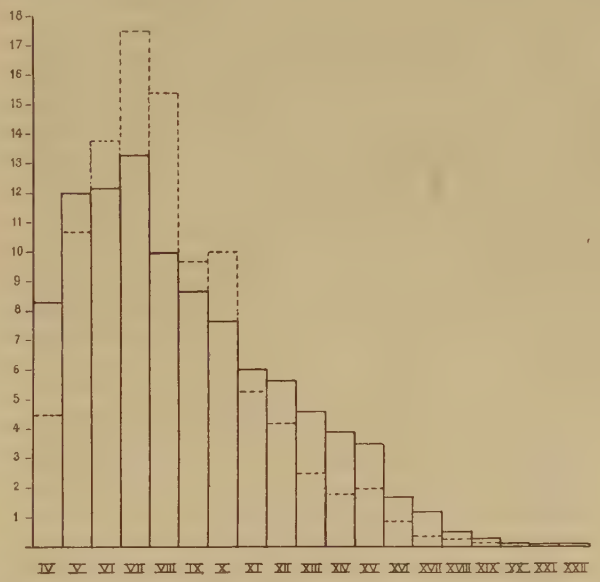

Fig. 31. Average Occurrence of the Age-Groups; continuous lines for the northern area, broken lines for the southern.

continuous lines indicate the average percentages of the different classes in zones I—VII for the period 1930—46, the broken lines the average percentages in zones VIII—IX for the same period. It is obvious, that there has been a far more uniform distribution of young, middle-aged and old cod in the northern area than in the southern, where young and old cod appear in much smaller proportions, whilst the middle-aged cod of the age-groups VI—X compose the largest part of the catches. We might have expected this from the size distribution of the cod in the two areas; the sizes being more evenly distributed in the northern area than in the southern, where the medium cod are in the majority. (See Fig. 28, p. 62.)

From the Angmagssalik district on the east coast our investigations into the composition of the stock refer only to the years 1931 and 1933. In these we find the same dominant year-classes as in the West Greenland cod (see Hansen 1934, p. 7).

In the Greenland stock of cod we have thus found at least nine rich classes which have been of import-

ance in the practical fishery. These were 1912, 1917, 1922, 1924, 1926, 1931, 1932, 1934 and 1936. For Iceland similar investigations on the fluctuations of the year-classes in the stock have been published by TÅNING (1931) and by FRIÐRIKSSON (1934 and 1943). SUND (1936) made a comparison of the fluctuations in European waters and in the north-western area. For Newfoundland THOMPSON (1943) has given some information regarding the fluctuations there. The same author has made a summary of the fluctuations in Norwegian, Icelandic, Greenland and American waters. At Iceland the year-classes 1912, 1917, 1922 and 1924 have been rich year-classes as at Greenland. On the other hand, the rich years 1913, 1915 and 1919 at Iceland have not shown themselves in any large quantities in the Greenland waters. The year-class 1926 was very rich at Greenland but does not seem to have been very important at Iceland. We may note here, that this year-class was only slightly represented in the recaptures of marked Greenland cod at Iceland.

Regarding the year-class 1931 FRIÐRIKSSON (1943) states, that it was present in 1939 on the Icelandic spawning grounds, where with the year-class 1930 it made up more than half of the stock. As the 1931 class had not been found abundantly in the immature stages at Iceland, FRIÐRIKSSON is of the opinion that it has grown up at Greenland and later migrated to Iceland to spawn. After the spawning of 1939 was over, the 1930 and 1931 classes were not found in any great quantities in the colder parts of Iceland (N. and E. coasts), from which FRIÐRIKSSON concludes, that it has migrated back again to Greenland. As we have seen, the 1931 class has been of some importance in some years in the Greenland waters. Its sudden decline in 1939 as well as the recovery of many marked Greenland cod of this class at Iceland makes it probable, that this year-class has gone to supplement the spawning stock at Iceland. But that it may have returned to Greenland after spawning, is not evident in the percentages for the Greenland catches.

The 1930 class has not been of any importance at Greenland whereas it has been richly represented at Iceland. The 1932 class, a rich year at Greenland, does not seem to have amounted to much at Iceland, whereas the 1934 class has been good in both Greenland and Iceland. The 1936 class, a very rich year at Greenland, occurred in fairly large quantities on the north-west and north coasts of Iceland in 1939 and has probably been a good year-class also in Icelandic waters.

Table 36. Cod Fluctuations.

Year-Class	Norway	Iceland	Greenland
1912	+	+	+
1913	—	+	—
1915	+	+	—
1917	+	+	+
1919	+	+	+?
1922	+	+	+
1924	+	+	+
1926	—	—	+
1929	+	—	—?
1930	+	+	—
1931	—	—	+
1932	—	—	+
1934	+	+	+
1936	—	+?	+
1937	+	—	—

The fluctuations in Greenland and Iceland thus only resemble each other to a certain extent. Most of the dominant classes in the Greenland stock have also been well-represented at Iceland, e. g., the year-classes 1912, 1917, 1922, 1924, 1934 and perhaps 1936. Some of the year-classes have been dominant in the one area, and not in the other, e. g., 1926, 1931 and 1932, rich at Greenland but not at Iceland; and the classes 1913, 1915, 1919 and 1930 which have been of importance at Iceland, but not at Greenland.

The fluctuations in Norwegian waters have been discussed in recent years by TÅNING (1931), SUND (1936) and ROLLEFSEN (1947). It appears that the classes 1912, 1917, 1922, 1924 and 1934 have been prominent years at Norway as at Greenland; besides these the year-classes 1915, 1919, 1929, 1930, and 1937 dominated at Norway, but were of less importance at Greenland. The rich Greenland classes 1926, 1931, 1932 and 1936 do not seem to have had any great importance in Norwegian waters.

For Newfoundland and Labrador the information given by THOMPSON is not so exact as to permit of a comparison between the different areas. It is stated for Labrador, that the classes 1924, 1925 and 1926 have been good.

The accompanying Table 36 indicates the year-classes of importance in the Norwegian, Icelandic and Greenland stocks of cod. + means a rich year-class, — a class of little importance.

VII. The relative Importance of the various Year-Classes in the Greenland Fisheries.

In the preceding section we have only dealt with the percentage quantities of the various year-classes of cod in the catches of the Greenlanders. We have now to consider, what the various year-classes have yielded both in number and weight in the years 1926 to 1946. By means of the total catches in the separate years, the percentages of the year-classes in the samples collected and the average lengths and weights of cod belonging to the different age-groups, we are able to calculate the number and weight of each year-class taken in the separate years.

Fig. 32 shows the number (columns) and weight (dotted lines) of the year-classes for the period 1926—1946. It gives some idea of the dominating

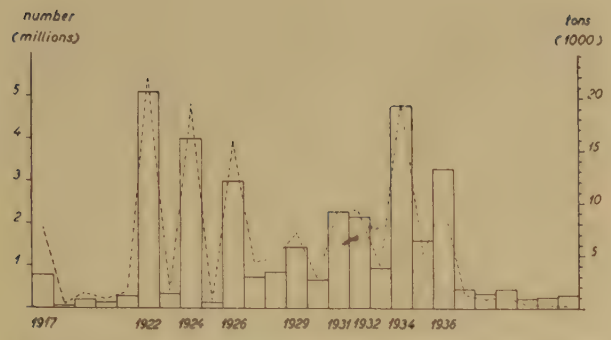

Fig. 32. Yield of the different Year-Classes of Cod in the period 1926—46.
Numbers: columns; Tons: broken lines.

importance of the large year-classes in the catches. The three year-classes, which have given the greatest yields both in number and weight, have been 1922, 1934 and 1924 with respectively 5·1, 4·8 and 4·1 million cod and 22·0, 19·3 and 19·5 thousand tons by weight.

The ten best classes in numbers have been: 1922, 1934, 1924, 1936, 1926, 1931, 1932, 1935, 1929 and 1917 in order of abundance. For the weight the order has been different, namely: 1922, 1924, 1934, 1926, 1936, 1931, 1932, 1917, 1929 and 1935. Comparison of the number with the weight curve shows whether the larger or smaller cod have been taken in any one year. For example, of the year-classes 1924 and 1934 the former is represented by 4·1 million cod, the latter by 4·8 millions, whilst the corresponding weights have been 19·5 and 19·3 thousand tons. The 1924 class has thus contributed to the fishery a smaller number but greater weight than the 1934 class, owing to the larger size of the cod. Similarly, the 1917 class shows a much greater weight than the 1935 class, namely 7·7 against 5·0 thousand tons, though the latter is represented by twice as many individuals as the 1917 class, namely 1·6 against 0·8 millions.

Fig. 33 shows by number and weight the product of the most important year-classes in the fishery of the Greenlanders, in each of the years 1926 to 1946.

From the curves in this figure it will be seen, that the various year-classes have increased their output in some years from the time when, as IV-group, they first appeared in the fishery. After a few years they reach a peak, then decrease somewhat in quantity; for some classes this decrease has been abrupt, for others more even. The 1922 and 1924 classes have gone down very sharply from the VIII- to the IX-group whilst the younger classes of 1931, 1932, 1934 and 1936 have all decreased much earlier, from the VI- to the VII-groups. Whilst the decrease of the older year-classes has continued, some of the younger classes have later increased, which may be ascribed in part to the more intensive fishery in recent years.

It seems reasonable to connect the sudden decrease in numbers with the inception of maturity and thus

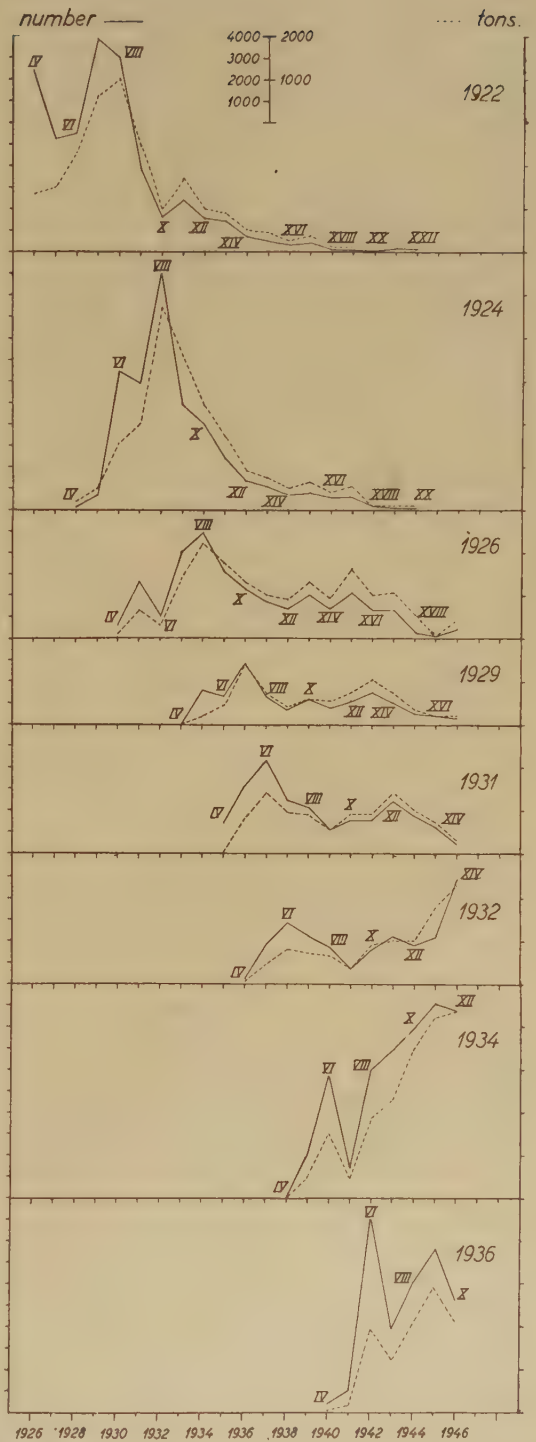

Fig. 33. Yield of the most abundant Year-Classes in the Fishery of the Greenlanders in the years 1926—46, given in numbers and tons.

with an emigration to spawning grounds elsewhere. Examination of the "spawning mark" in the otoliths has shown indeed, that the older year-classes reached maturity at a greater age than the younger classes, in which maturity for the most part sets in about the seventh year. The ages at first-maturity correspond well with the years when the great decrease occurs.

Comparing the curve for the total product of the fishery of the Greenlanders (Fig. 1) with that for the total product of the Norwegian fishery at the Lofoten (Fig. 34) we see that great fluctuations occur in both cases. With regard to the Norwegian fishery ROLLEFSEN has suggested, that the annual fluctuations may be due to meteorological and hydrographical conditions, whereas fluctuations of 3—5 years duration can be traced back to the size or amounts of definite year-classes. Fluctuations of about 20 years duration are probably due to a shrinkage or expansion of the stock over a long period.

The high peak in the Lofoten curve at the end of the twenties has come from the three rich years 1917, 1918 and 1919, especially the last. In the beginning of the thirties these year-classes have declined and the product of the fishery reduced, but at the end of the thirties the rich 1929 and 1930 classes have led again to an increase. About the middle of the forties the product falls once more, to rise sharply in 1946 and 1947 on the appearance of the very abundant 1937 class.

In the fishery of the Greenlanders we see, that the yield has been good in the years 1930—34, due to the three good year-classes 1922, 1924 and 1926, especially the first. Then comes a period of lean years from 1935 to 1941. In this the three year-classes 1922, 1924 and 1926 have greatly decreased, and the 1931 and 1932 classes are not rich enough to counterbalance the decrease. From 1942 to 1947 there is again a rise in the yield, due especially to the 1934 and 1936 classes, the former of which has been specially abundant.

The yield of the fishery in the two areas thus varies according to the occurrence of good or poor year-classes. The fluctuations vary according to the dominance of various year-classes in the two areas.

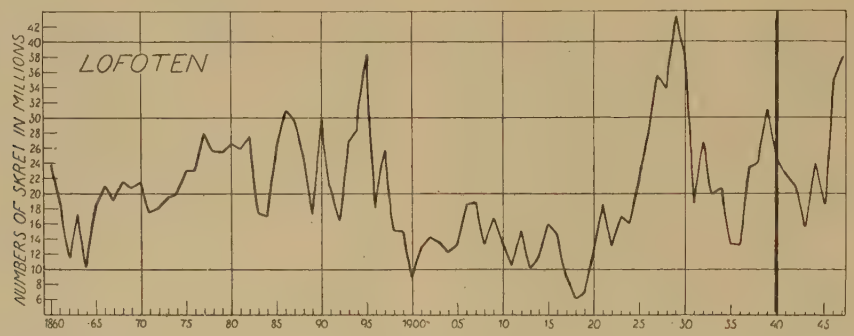

Fig. 34. The Output of the Lofoten Fishery in millions of Skrei. After ROLLEFSEN 1948.

VIII. Concluding Remarks and Future Work.

This account of the investigations on the biology of the cod in Greenland waters has thrown light on a number of the phases in the life-history of the cod; yet several problems still remain. What has been learnt so far may be briefly summarized here, as also what investigations are still necessary.

The hydrographical conditions in the waters of Greenland have been discussed in Section III. But, even though the main lines are now known, we see that these hydrographical conditions can vary greatly from year to year. It will therefore be of interest and importance, to take each year several hydrographical sections from the coast out over the banks, to ascertain the varying extent of the distribution of the polar water and the Atlantic Current in the different years. If, for example, a reversion took place to the less favourable temperatures of earlier years, it will be of great importance to be able to follow such a development. Connected with this also changes in the marine fauna must be kept under observation, so that we may be able to note any variation in the distribution of the various marine animals. Such changes have also been noted in other waters and a beginning has already been made by the International Council for the Exploration of the Sea, to collect observations on this subject from all waters.

The distribution of the cod fry must constantly be under observation. We must find out especially how far to the north their distribution extends and what changes occur in this distribution.

The spawning grounds of the cod should be the object of special investigation, on the one hand by searching for the spawning cod and tiny fry in the Davis Strait in the spring months—field work of a fairly difficult character, on the other by using the echo-sounder on the spawning grounds in the fjords,

e. g. Godthaab Fjord, to determine the depths and the temperature at which spawning takes place. Preparations have already been made to carry out such investigations, as it has been arranged that the research vessel M/K "Adolf Jensen", so far as the conditions permit, will work on the Fylla Bank and in Godthaab Fjord in the early spring of 1948.

The age of the cod at first-maturity has constantly to be investigated, the samples of otoliths collected every year being examined not only for analysis of the age but also for the number of spawning zones. These investigations have shown, namely, that great differences may occur in the age at first-maturity for the different year-classes.

With regard to the growth of the cod, great differences have also been found in this respect in the different year-classes. The otolith samples and length measurements collected yearly at the different fishing stations and by the research vessels will provide excellent material for such investigations.

So far as the food of the cod is concerned, the investigations have so far been mainly superficial. It is desirable to have investigations of a more quantitative character. So far it has been difficult to make such investigations from the small vessels available. It would be better to undertake them from a station on land. They should also be carried on throughout a whole season, to determine variations in the quantity of food at different times. More complete information regarding the occurrence and changes in quantity of the principal food-animals, such as capelan and lance should be sought and also, the amount of food in the cod stomachs. Both old and young cod should be examined.

The numerical characters, number of vertebrae and rays in D_2, are hardly worth investigating, the variations within the restricted area of the Greenland waters being insignificant. The results obtainable are out of all proportion to the immense, time-wasting labour involved in such investigations.

With regard to the migrations of the cod, the marking experiments have yielded such interesting results, that they should be continued every year. Special importance attaches to the marking of cod in the Julianehaab district, from which it is known that the greatest migration to Iceland takes place, but similar experiments in the northern districts should not be neglected. It would be of importance to have marking experiments in some years from localities evenly distributed over fjords, coastal areas and the off-shore banks within the whole field of distribution of the cod at West Greenland.

It is desirable likewise, that continuous marking experiments should be made at Iceland, especially on the cod spawning grounds there, in order to ascertain whether a return migration of spent cod to Greenland occurs regularly.

In the investigations on the Greenland cod most weight has been laid on determining the fluctuations in the quantities of the different year-classes in the stock. The practical importance of such investigations for determining the prospects of the future fishery is obvious. It has proved, that investigations of this kind on the quantities of cod in the earliest age-groups can in most cases yield an estimate of the probable product of the fishery some four to five years ahead. Observations on the occurrence of the three youngest age-groups are thus of great importance and the search for these groups with eel-seine at suitable localities will be continued. Collection of otoliths to determine the importance of the different year-classes in the catches will likewise continue, as it is of interest to determine how long any dominant year-class continues prominent in the catches. Investigation has shown, that the different year-classes vary greatly in this respect. For example, the year-class 1934 has remained much longer prominent in the catches than the previously known rich year-classes.

Finally, the wish may be expressed, that in other areas where cod investigations are carried on, similar yearly analyses of the stock should be made to determine the good and bad years. Such investigations are being made in Norway, the Faroes and Iceland, but are lacking in the whole American region, from Labrador, Newfoundland and the U.S.A., where an intensive cod fishery is carried on. It would be extremely desirable to have these areas included in these investigations, so as to obtain a complete picture of the composition of the stock in the whole region of distribution. Comparisons between the areas with regard to the composition of the stocks in good or bad year-classes together with observations on the hydrographical and possibly other factors affecting the composition would lead to a fuller comprehension of the changes and fluctuations which are of such importance for the commercial fishery.

Summary.

The *occurrence* of the cod in Greenland waters has been periodic. The present period, the longest known, began in the twenties and has arisen from a favourable change in the hydrographical conditions. This warm period has been marked by changes in the distribution of several species in the Greenland waters.

The stock of cod at West Greenland may be divided roughly into a northern part, living in the waters north of the Frederikshaab district as far as the most northerly occurrence of the species up towards Upernivik and including the off-shore banks in the Davis Strait, and a southern part living in the Julianehaab and the Frederikshaab districts. There is no sharp delimitation between the two, and the conditions

cannot yet be said to be wholly elucidated. In addition, local populations are to be found in certain fjords.

At East Greenland the cod occurs in the Angmagssalik district, but very little is as yet known about its occurrence at the southern part of the east coast. The *spawning grounds* of the northern stock have not yet been precisely determined, but it may be assumed that the cod spawns in the Davis Strait, possibly in the warm Atlantic water on the slope of the marine banks, and sporadically in the coastal area between ca. 63° and 67° N. L. From there the fry are carried northwards with the current. Some of the cod spawn in Icelandic waters, but this emigration is of far less extent than from the southern area of Julianehaab and Frederikshaab. The small cod of the age-groups I and II have been found growing up in Disko Bay and the northern Vajgat, and in small numbers in Umanak Fjord.

The cod in the districts of Julianehaab and Frederikshaab have a close connection with Iceland, having their spawning places on the south and west coasts of that island, whence the fry are carried with the current over to Greenland, where on the southwest coast large numbers of the I- and II-groups have been discovered. The East Greenland stock at Angmagssalik has also a close connection with Iceland.

The local populations occurring in Ikertok, Kangia and the Godthaab Fjord spawn within the fjord. Fairly large numbers of the fry are apparently carried out of Godthaab Fjord and spread along the coastal area. An important spawning ground of the cod has been found in one of the innermost arms of the Godthaab Fjord, at Kapisigdlit.

In *numerical characters*, number of vertebrae and number of rays in D_2, the northern group is distinguished from the southern in having a higher number of vertebrae. The number of vertebrae in the southern group and the population on the east coast is very close to what has been found for the cod at Iceland. There is no agreement between the Greenland and Newfoundland cod in regard to number of vertebrae. Whilst the cod of Godthaab Fjord are distinguished from the cod of the coast and banks chiefly by the structure of the otoliths and less by the numerical characters, the stocks in Ikertok and Kangia have respectively higher and lower values for the number of vertebrae than the cod in other localities. These two stocks may be regarded as old accumulations in contrast to the cod in Godthaab Fjord which are possibly a mixture of an old stock with cod from outside.

It has been shown, that *maturity* begins at an earlier stage in the younger than in the older year-classes of cod; this holds good for both the northern and southern groups of cod. The curves for the age at first-maturity have however a somewhat different character in the two areas (Fig. 11).

The *growth* shows certain differences in the different groups. For a long period the average lengths of the various year-classes have been greater in the northern than in the southern cod. This has now changed and the lengths of the year-classes occurring in the Julianehaab district do not show any essential difference from the corresponding lengths in the northern group. This has been caused by the slower growth of the later year-classes (1931, 1932, 1934 and 1936) by comparison with the older (1922, 1924 and 1926). This decrease in growth has been greater in the northern districts than in Julianehaab. With regard to the fjord population, we have only material from the Godthaab Fjord for any number of years, and this shows an even greater decline in the average lengths than is apparent in other Greenland localities. The fjord populations in Ikertok and Kangia seem to have a slower growth than the cod in the coastal area. The capelan and lance play a great part in the food of the cod and give rise to more or less extensive migrations.

Marking experiments over a number of years have shown that the cod migrate to Iceland from most of the West Greenland localities right up to Egedesminde. From the northern districts there is but little emigration, but it is very considerable from the Frederikshaab and Julianehaab districts. This is a spawning migration, taking place in the late autumn and winter to spawning places at Iceland. There is a migration in the opposite direction, which seems to have a still more periodic character than the spawning migration. We cannot say whether it is a general rule, that the Greenland cod after spawning at Iceland return to Greenland waters. The greatest number of marked cod, which have migrated from Iceland, have been retaken on the northern banks. It may be mentioned, that in the year 1931 when most of these recaptures were made, a great many cod were caught north of the marking localities at Greenland. Special spawning places for the cod at Greenland have not been disclosed by the marking experiments. One exception however is Kapisigdlit in the Godthaab Fjord, but this is only a spawning ground for the local fjord population and some few cod from the adjacent coastal and bank areas, Fylla Bank. Marking experiments on the cod in Ikertok, Kangia and Godthaab Fjord have yielded a very large number of recaptures from the place of marking and its neighbourhood. From these marking experiments there have been but few returns from Iceland.

Recaptures of marked Greenland cod at Iceland continue in the first seven years after marking, but most are retaken in the year after marking. Whilst recaptures in the northern part of Greenland continue for a long series of years (up to 10—13 years), no cod in the Frederikshaab and Julianehaab districts have been retaken later than seven years after marking. The ages of the cod recaptured at Iceland are different for those marked in the northern districts and those marked in the Frederikshaab—Julianehaab district. In the former the cod mainly belong to the X- and XI-groups, in the latter to the age-groups VII—IX. Of the cod retaken at Iceland those marked in the northern part of Greenland have been larger than those marked in the Julianehaab district.

With regard to the *size* of the cod caught by the

Greenlanders it has been found, that the lengths in the northern area represent a fairly even mixture of small, medium and large cod, whereas the cod in the southern districts are mainly of the medium size. In agreement with this we find from the distribution of the age-classes in the catches, that there is a much more equal distribution in the northern area than in the southern, where cod of the middle ages dominate.

The different year-classes persist longer in the northern than in the southern area. *Fluctuations* of the year-classes are more marked in the Greenland stock of cod than in other regions where cod occur. During the period 1926—1946 there have been eight rich year-classes, which have been dominant in the catches. These were from the years 1917, 1922, 1924, 1926, 1931, 1932, 1934 and 1936. Several of these year-classes have been identified already as I- and II-groups in the eel-seine catches at the coast.

Differences have been found in the occurrence of the year-classes in the northern and southern areas; for example, the 1924 class has been more prominent in the southern than in the northern. On the other hand, the 1926 class has been more numerous in the northern stock. This may account for the fact, that this 1926 class has been poorly represented in the recaptures of Greenland cod at Iceland, since the most extensive emigration takes place from the southernmost districts.

Comparison of the results from Greenland, Norway and Iceland with regard to the fluctuations of the different year-classes, has revealed fairly large differences between them (Table 36).

The importance of the different year-classes for the fishery of the Greenlanders has been indicated by numbers and weight in Fig. 33. The 1922 class has had the greatest importance hitherto, but in a few years it will probably be superseded by the 1934 class, which has been unusually abundant. For nearly the whole war period the 1934 and 1936 classes have been quite dominant in the catches of the Greenlanders.

Literature.

Annales Biologiques. 1943: Vol. I, 1939—41. North-Western Area. Contributors: Árni Fridriksson, Paul M. Hansen, Adolf Kotthaus, Å. Vedel Tåning. Cons. Internat. Explor. Mer., Copenhague.

— 1947: Vol. II, 1942—1945. North-Eastern Area Report. Gunnar Rollefsen: Cod (Skrei). North-Western Area Report. Cons. Internat. Explor. Mer, Copenhague.

Braarud, T. & Ruud, Joh. T. 1932: The "Øst"-Expedition to the Denmark Strait. 1929. I. Hydrography. Hvalrådets Skrifter Nr. 4, Oslo.

Bulletin Statistique des Pêches Maritimes. 1925—1938: Vol. XV—XXVIII. Cons. Internat. Explor. Mer, Copenhague.

Devold, F. 1947: Fiskeriene ved Vestgrønland. Fiskets Gang 33. Aarg. Nr. 44, pp. 522—525. Nr. 45, pp. 535—537. Bergen.

Dunbar, M. J. 1946: The State of the West Greenland Current up to 1944. Journal of the Fisheries Research Board of Canada, Vol. VI, No. 7. Toronto.

Fiskeriberetninger. Beretninger og Kundgørelser vedr. Styrelsen af Grønland. Aarene 1911—1947. København.

Fridriksson, Á. 1929: Age-Composition of the Stock of Cod in East Iceland Fjords during the Years 1925—27. Rapp. et Proc.-Verb. Vol. LVII, Copenhague.

Fridriksson, Á., Hansen P. M., Bruun, A. F. & Vedel Tåning, Å. 1934: Report concerning the Analysis of Cod Otoliths from Iceland. Rapp. et Proc.-Verb. Vol. LXXXVI, Copenhague.

Fridriksson, Á. 1940: Investigations carried out by the Fisheries Department of the University Research Institute Reykjavik in the Years 1937—1939. Atvinnudeild Haskolans. Rit Fiskideildar 1940, Nr. 1. Reykjavik.

Graham, Michael. 1934: Report on the North Sea Cod. Min. Agric. and Fish., Fish. Invest., Ser. II, Vol. XIII, No. 4. 1933.

Hansen, Paul M. 1931: Undersøgelser over den grønlandske Torsk. Beretninger og Kundgørelser vedr. Styrelsen af Grønland. No. 4, p. 705—711. København.

Hansen, Paul M. 1934: Synopsis of investigations into Fluctuations in the Stock of Cod at Greenland during the years 1930—1933. Rapp. et Proc.-Verb. Vol. LXXXVI. Copenhague.

Hansen, Paul M., Jensen, Ad. S. & Vedel Tåning, Å. 1935: Cod Marking Experiments in the Waters of Greenland 1924—1933. København.

Hansen, Paul M. 1939: The Age-Composition of the Stock of Cod in West Greenland Waters in the Years 1924 to 1938. Rapp. et Proc.-Verb. Vol. CIX. Copenhague.

— Fiskeriundersøgelser ved Vestgrønland. Beretninger og Kundgørelser vedr. Styrelsen af Grønland. Aarene 1932—1940 & 1947. København.

Hermann, F. & Thomsen, H. 1946: Drift-Bottle Experiments in the northern Atlantic. Medd. Komm. Danmarks Fiskeri- og Havunders., Ser. Hydrografi. Bd. III, No. 4. København.

Hjort, Johan. 1909: Rapport sur les travaux de la Commission A, 1902—07 (On Gadidae). Rapp. et Proc.-Verb. X. Copenhague.

— 1914: Fluctuations in the great Fisheries of Northern Europe. Rapp. et Proc.-Verb. XX. Copenhague.

— 1926: Fluctuations in the Year-Classes of important foodfishes. Journ. du Conseil. Vol. I, 1. Copenhague.

Hjort, Johan & Ruud, Joh. T. 1929: Whaling and Fishing in the North Atlantic. Rapp. et Proc.-Verb. LVI, 1. Copenhague.

Idelson, M. 1930: On the Nourishment of the Food Fishes in the Barents Sea. Hydrobiologische Zeitschrift herausgegeben von der Biologischen Wolga-Station. Band VIII, No. 10—12. Saratov.

— 1931: Fish Marking in the Barents Sea. Journ. du Conseil. Vol. VI, 3. Copenhague.

Iversen, Thor. 1933: Nogen Iakttagelser over fiskeyngel i trålfangster i Barentshavet. Rep. Norw. Fish. and Mar. Invest. Vol. IV, No. 5. Bergen. English version see: Some Observations on Fry in Trawl Catches in the Barents Sea. Rapp. et Proc.-Verb. Vol. LXXXV, pt. 3, 1. Copenhague.

— 1933: Some Observations on Cod in Northern Waters. Rep. Norw. Fish and Mar. Invest. Vol. IV, No. 8. Bergen.

Iversen, Thor. 1936: Sydøstgrønland Jan Mayen. Fiskeriundersøkelser. Fiskeridirektoratets Skrifter, Ser. Havundersøgelser. Vol. V, No. 1. Bergen.
Jensen, Aage J. C. 1939: On the Laws of Decrease in Fish Stocks. Rapp. et Proc.-Verb. Vol. CX. Copenhague.
Jensen, Ad. S. 1909: Indberetninger om Fiskeriundersøgelserne i 1908. Beretninger og Kundgørelser vedr. Kolonierne i Grønland. Nr. 2, pp. 11—32. København.
— 1909: Beretning om Fiskeriundersøgelserne ved Grønland. Beretninger og Kundgørelser vedr. Kolonierne i Grønland. Nr. 5, p. 73—106. København.
— 1922: *Sebastes marinus*. Vidensk. Meddel. fra Dansk naturhist. Foren., Bd. 74, p. 90. København.
— 1925: On the Fishery of the Greenlanders. Medd. Komm. Havunders., Ser. Fiskeri. VII, 7. København.
— 1926: Investigations of the "Dana" in West-Greenland Waters, 1925. Rapp. et Proc.-Verb. Vol. XXXIX, p. 97. Copenhague.
Jensen, Ad. S. & Hansen, P. M. 1931: Investigations on the Greenland Cod (*Gadus callarias* L.). With an Introduction on the History of the Greenland Cod Fisheries. Rapp. et Proc.-Verb. LXXII. (I). Copenhague.
Jensen, Ad. S. 1939: Concerning a Change of Climate during recent Decades in the Arctic and Subarctic Regions, from Greenland in the West to Eurasia in the East, and contemporary biological and geophysical Changes. Det Kgl. Danske Videnskabernes Selskab. Biolog. Medd. XIV, 8. København.
— 1944: Klimasvingninger over Arktis og deres Følgevirkninger med særligt Henblik paa Grønland. Det Grønlandske Selskabs Aarsskrift. Pag. 7—19. København.
Kilerich, A. 1943: The Hydrography of the West Greenland Fishing Banks. Medd. Komm. Danmarks Fiskeri- og Havunders., Ser. Hydrografi. Bd. 3, Nr. 3. København.
— 1945: On the Hydrography of the Greenland Sea. Medd. om Grønland. Bd. 144, Nr. 2. København.
Løversen, R. 1946: Torskens vekst og vandringer på Sørlandet. Rep. Norw. Fish. and Mar. Invest. Vol. VIII, Nr. 6.
McKenzie, R. A. 1934: Cod Movements on the Canadian Atlantic Coast. Contrib. Canad. Biol. and Fish., N. S. Vol. VIII, No. 31. Toronto.
— 1934: Cod tagging along outer Coast of Nova Scotia. Ann. Rep. Biol. Board of Canada 1933. Ottawa.
Meschkat, A. 1936: Untersuchungen über den Aufbau der Kabeljaunahrung im Bereich der Vestmannainseln. Rapp. et Proc.-Verb. Vol. XCIX. Copenhague.
Messiatzeva, E. 1932: Chief Results of the Fishery Research in the Barents Sea in 1930 by the Goin (State Oceanographical Institute of U.S.S.R.). Rapp. et Proc.-Verb., Vol. LXXXI. Copenhague.
Moltke, C. 1896: Temperatur og Saltholdighedsmaalinger af Fjordvand. Medd. om Grønland. Bd. 16, p. 108—122. København.
Nielsen, J. N. 1928: The Waters Round Greenland. Greenland Vol. I, pp. 185—230. Copenhagen.
Oldendow, Knud: Tilstandene i Grønland 1946. København.
Porsild, M. P. 1945: Sjældne grønlandske Fisk. Grønlandsposten 4. Aarg. Nr. 17, pag. 240—241. Godthaab.
Poulsen, Erik M. 1931: Biological investigations upon the Cod in Danish Waters. Medd. Komm. Danmarks Fiskeri- og Havunders., Ser. Fiskeri, Vol. IX, No. 1. København.
Rollefsen, G. 1933: The Otoliths of the Cod. Rep. Norw. Fish. and Mar. Invest. Vol. IV, No. 3. Bergen.
Rollefsen, G. 1934: The Cod Otoliths as a Guide to Race, Sexual Development and Mortality. Rapp. et Proc.-Verb. Vol. LXXXVIII. Copenhague.
— 1938: Changes in Mean Age and Growth-Rate of the Year Classes in the Arcto-Norwegian Stock of Cod. Rapp. et Proc.-Verb. Vol. CVIII, I. Copenhague.
— 1942: Litt om skreiens dødelighet. The Fish and the Sea. Rep. Norw. Fish. and Mar. Invest. Vol. VII, No. 6. Bergen.
— 1947: The Cod (Skrei). (North-Eastern Area Report) Ann. Biolog. Vol. II, 1942—1945. Copenhague.
— 1948: The Arcto-Norwegian Stock of Cod. Rapp. et Proc.-Verb. Vol. No. 122, No. 1. Copenhague.
Schmidt, Johs. 1905: The pelagic Postlarval Stages of the Atlantic species of Gadus. Part 1. Medd. Komm. Havunders., Ser. Fiskeri. Bd. 1, Nr. 4. København.
— 1907: Marking experiments on Plaice and Cod in Icelandic Waters. Medd. Komm. Danmarks Fisk.- og Havunders., Ser. Fiskeri Bd. II, Nr. 6. København.
— 1926: The Frequency of young Cod etc. on the North- and East Coasts of Iceland during a period of years. With a Survey of the Life-History of the Icelandic Cod. Rapp. et Proc.-Verb. Vol. XXXIX. Copenhague.
— 1930: Racial Investigations. X. The Atlantic Cod (*Gadus callarius* L.) and local races of the same. Comptes-Rendus des Trav. du Laboratoire Carlsberg XVIII, Nr. 6. Copenhague.
— 1931: Summary of the Danish Marking experiments on Cod 1904—1929, at the Faroes, Iceland and Greenland. Rapp. et Proc.-Verb. LXXII (III). Copenhague.
Schroeder, W. C. 1930: Migrations and other Phases in the Life History of the Cod off Southern New England. U. S. Dept. of Commerce, Bull. Bur. Fish. Vol. XLVI. Washington.
Sivertsen, E. 1935: Torskens Gytning. Rep. Norw. Fish. and Mar. Invest. Vol. IV, No. 10. Bergen.
— 1937: Torskens Gytning. Undersøgelser 1934—35. Rep. Norw. Fish. and Mar. Invest. Vol. V, No. 3. Bergen.
Smed, Jens. 1947: Monthly Anomalies of the Surface Temperature in the Sea round South Greenland during the Years 1876—1939. Ann. Biol. Vol. II. Copenhague.
Statistiske Oplysninger om Grønland. I. Beretn. vedr. Grønlands Styrelse. Nr. 1. 1942. København.
Stephensen, K. 1947: Mærkeligt Fund af to tropiske (subtropiske) Krebsdyr ved Thule. Naturhist. Tidende. 11. Aarg., No. 2. København.
Strubberg, A. C. 1916: Marking experiments with Cod at the Faroes. Medd. Komm. Havunders. Ser. Fiskeri V, No. 2. København.
— 1933: Marking Experiments with Cod at the Faroes. II. Second Report Experiments in 1923—27. Medd. Komm. Havunders., Ser. Fiskeri IX, No. 7. København.
Sund, Oscar. 1929: Torskemerkningen 1928. Årsber. Norges Fiskerier, 1928, Hefte 1. Bergen.
— 1930: The Renewal of a Fish Population studied by Means of Measurement of Commercial Catches. Example: the Arcto-Norwegian Cod Stock. Rapp. et Proc.-Verb. Vol. LXV. Copenhague.
— 1932: Merkning af Torsk. Beretning om Lofotfisket 1931. Bergen.
— 1932: On the German and Norwegian Observations on Cod in 1931. Rapp. et Proc.-Verb. Vol. LXXXI. Copenhague.
— 1934: Cod-Measurements during 21 Years on the Western and Northern Coasts of Norway. Methods and

Results. Rapp. et Proc.-Verb. Vol. LXXXVIII. Copenhague.

Sæmundsson, B. 1909: Oversigt over Islands Fiske. Skrifter udgivne af Komm. for Havunders. No. 5. København.

— 1913: Continued marking experiments on Plaice and Cod in Iceland Waters. Medd. Komm. Havunders., Ser. Fiskeri. IV. No. 6. København.

— 1923: On the Age and Growth of the Cod (*Gadus callarias* L.) in Icelandic Waters. Medd. Komm. Havunders., Ser. Fiskeri VII, 3. København.

— 1926: Fiskarnir. Islensk Dyr. I. Reykjavik.

— 1927 a: Zoologiske Meddelelser fra Island XV. Vidensk. Medd. fra Dansk naturh. Foren. Bd. 84. København.

— 1927 b: Synopsis of the Fishes of Iceland. Rit Visindafélags Islendinga II. Reykjavik.

— 1934: Probable influence of Changes in Temperature on the Marine Fauna of Iceland. Rapp. et Proc.-Verb. Vol. LXXXVI. Copenhague.

Tåning, Å. Vedel. 1929: Plaice investigations in Icelandic Waters. Rapp. et Proc.-Verb. Vol. LVII. Copenhague.

— 1931: Fluctuations in the Stock of Cod in Icelandic Waters. Medd. Komm. Havunders., Ser. Fiskeri IX, No. 3. København.

Tåning, Å. Vedel. 1933: A Method for Marking Cod. Capt. Hansen's Marking Needle. Journ. du Conseil. Vol. VIII, 3. Copenhague.

— 1934: Survey of Long Distance Migrations of Cod in the North Western Atlantic according to Marking Experiments. Rapp. et Proc.-Verb. Vol. LXXXIX, III, 2. Copenhague.

— 1937: Some Features in the Migrations of Cod. Journ. du Conseil. Vol. XII, No. 1. Copenhague.

— 1940: Migrations of Cod marked on the spawning places off the Faroes. Medd. Komm. Danmarks Fiskeri- og Havunders., Ser. Fiskeri. Bd. X, No. 7. København.

— 1943: Fiskeri og Havundersøgelser ved Færøerne. Skrifter udgivet af Komm. f. Danmarks Fiskeri- og Havunders. København.

— 1944: Experiments on Meristic and other Characters in Fishes I. Medd. Komm. Danmarks Fiskeri- og Havunders., Ser. Fiskeri. Bd. XI. København.

Thompson, Harold. 1943: A biological and economic study of Cod (*Gadus callarias*, L.) in the Newfoundland area. Newfoundland Government. Research Bulletin No. 14. St. Johns.

Vibe, Chr. 1945: Ny Fisk til Grønlands Kyster. Grønlandsposten 4. Aarg. Nr. 1, p. 5. Godthaab.